COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Engineering Library

January, 1947

Installing third boiler at Port Washington Station

Further Topping at Sherman Creek, Part I—Steam Generation ▶

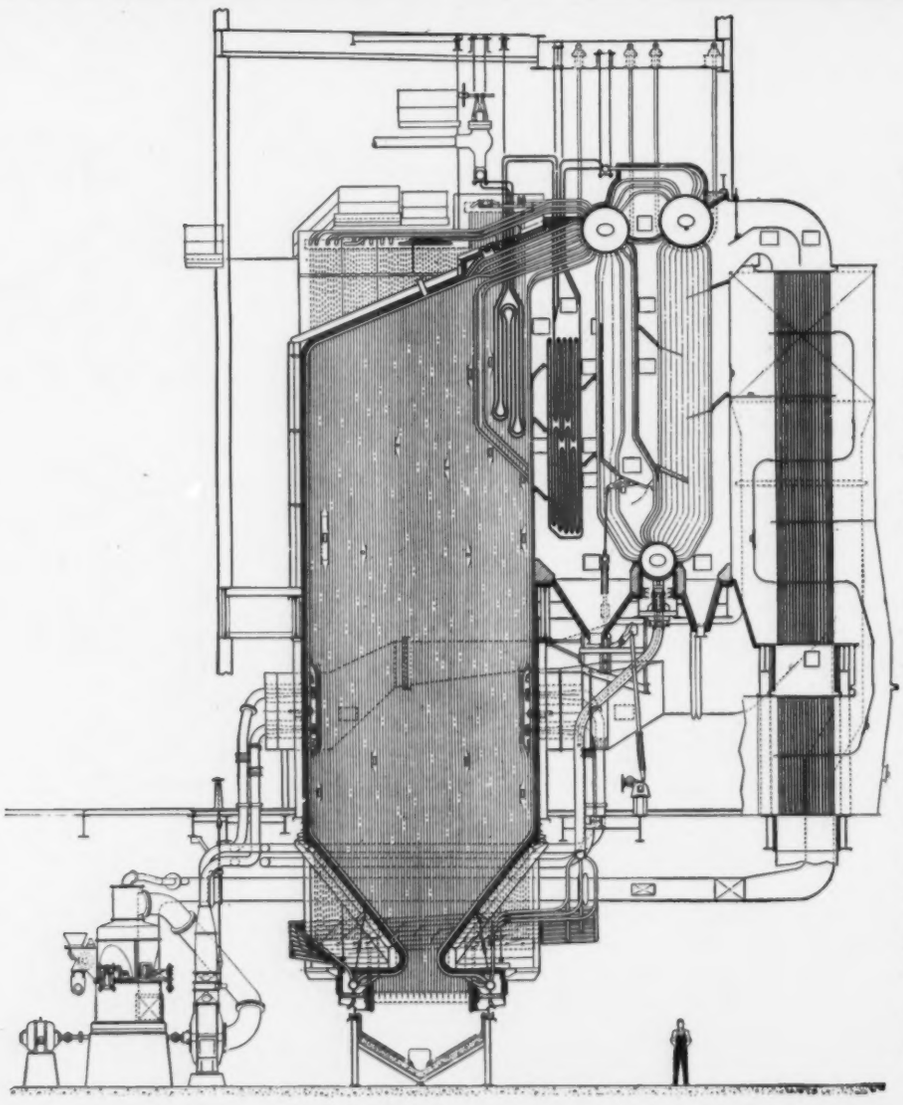
Electric Energy Production ▶

Port Washington Performance for 1946 ▶

Recent C-E Steam Generating Units for Utilities

NEW POWER STATION

ILLINOIS POWER COMPANY



The C-E Unit, illustrated here, is now under construction in the New Power Station of the Illinois Power Company at Havana, Illinois.

It is one of six duplicate units for this station designed for a pressure of 950 psi, a total steam temperature of 910 F and a maximum continuous capacity of 285,000 lb of steam per hr.

These units are of the 3-drum type with completely water-cooled, basket-bottom furnace. They are pulverized coal fired using C-E Raymond Bowl Mills and vertically-adjustable, tangential burners. The Elesco Superheaters are of the two-stage type. Superheat temperature control is assured by virtue of the vertically-adjustable burners in conjunction with remote manually regulated bypass dampers. C-E Tubular Air Heaters follow the boiler surface.

B107

COMBUSTION ENGINEERING

200 MADISON AVENUE · NEW YORK 16, N. Y.

C-E PRODUCTS INCLUDE ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME EIGHTEEN NUMBER SEVEN

CONTENTS

FOR JANUARY 1947

FEATURE ARTICLES

Further Topping at Sherman Creek, Part I—Steam Generation ..... *by R. T. Roberts* 24
Electric Energy Production in the United States 29
Port Washington Performance for 1946 31
Feed Distribution and Hunting in Marine Boilers ..... *by H. Hillier* 35
Short Cut in Vapor Calculations ..... *by A. H. Zerban* 37
Standardized Turbine-Generator Units ..... *by J. R. Carlson* 38
Report of Water Conference 41

EDITORIALS

Costly Insurance 23
Off to a Good Start 23
Sustained Performance 23

DEPARTMENTS

Catalogs and Bulletins 45
Advertisers in This Issue 48

JOHN L. WILLIAMSON, *General Representative*
ALFRED D. BLAKE, *Editor*
THOMAS E. HANLEY, *Circulation Manager*

Published monthly by COMBUSTION PUBLISHING COMPANY, INC., 200 Madison Ave., New York 16
A SUBSIDIARY OF COMBUSTION ENGINEERING COMPANY, INC.

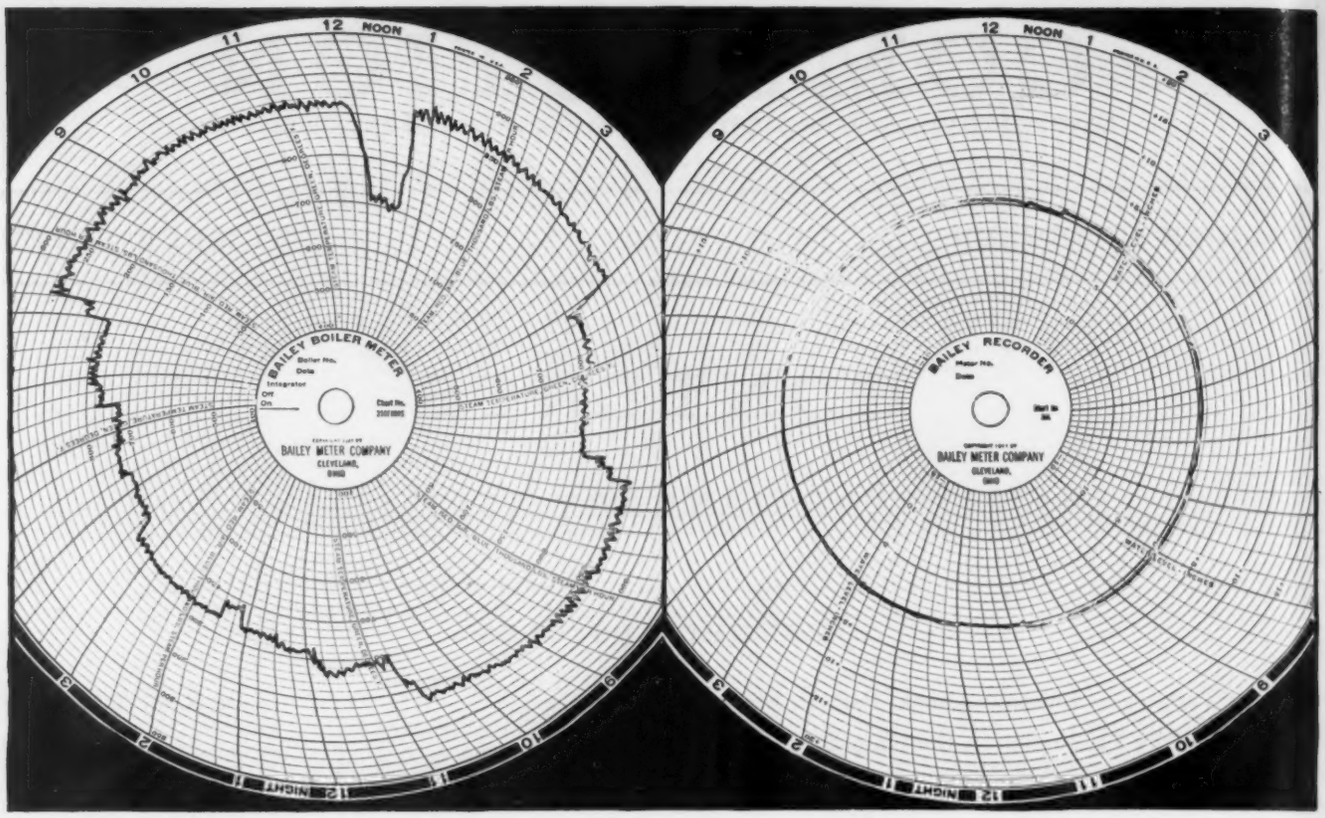
Frederic A. Schaff, President; Charles McDonough, Vice-President; H. H. Berry, Secretary and Treasurer.

COMBUSTION is sent gratis to engineers in charge of steam plants from 500 rated boiler horsepower up and to consulting and designing engineers in this field. To others the subscription rate, including postage, is $2 in the United States, $2.50 in Canada and Great Britain and $3 in other countries. Single copies: 25 cents.
Copyright 1946 by Combustion Publishing Company, Inc.
Issued the middle of the month of publication.

Publication office, 200 Madison Ave., New York CCA Member of the Controlled Circulation Audit, Inc.

Printed in U. S. A.

Engineering Library



COPES AT WESTOVER STATION

OF NEW YORK STATE ELECTRIC AND GAS CORPORATION

Boiler loads at Westover Station at times fluctuate more than you might expect in an 875-psi, 885-F utility installation. Yet COPES Flowmatic closely stabilizes boiler water level, as shown by the charts, on the two Foster Wheeler three-drum, bent-tube steam generators. Except for shrink and swell, the level is held within one inch by two-element COPES Control. The story is told in Bulletin 463—Boiler Feed Control at Westover, Greenidge and Jennison Stations. Write—your letterhead, please—for this 16-page report.

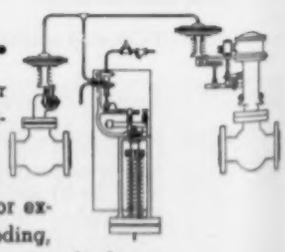
NORTHERN EQUIPMENT COMPANY
176 GROVE DRIVE, ERIE, PENNSYLVANIA
Feed Water Regulators, Pump Governors, Differential Valves, Liquid Level Controls, Reducing Valves and Desuperheaters
BRANCH PLANTS: Canada, England, France • *Representatives Everywhere*

★ GET CLOSER LEVEL CONTROL WITH COPES FLOWMATIC

DESUPERHEATER...

Here's a desuperheater every bit as effective on light loads as at full capacity. No water dribbles into the steam line. There is complete atomization of the cooling water from zero to full load because the opening of the spray nozzle—not the pressure drop across it—is varied with steam temperature. A self-contained unit, as *dependable* as the COPES Feed Water Regulator. Write for Bulletin 405-A.

MASTER CONTROL...



Remote control of reduced water or steam pressures, with single or multiple pressure reducing stations, is *dependably* accurate with the COPES Master Control. Adapted for excess pressure control in boiler feeding, where one or more turbine-driven pumps discharge into a common water header. Details on request.

EDITORIAL

Costly Insurance

As reported in the daily press, an official of one of the large electric utility companies, testifying recently at a Public Service Commission hearing, stated that his company desired to build up a coal reserve of $1^1/_2$ million tons, as a safeguard against possible future stoppages in either production or delivery of coal. The cost of such a reserve, at current prices, he estimated at over 12 million dollars—a sizeable sum to tie up for such insurance. But this is only one of many companies, both utility and industrial, that are finding it necessary to take such measures to varying degrees.

According to Government figures, stocks of coal on hand at electric utility power plants on November first amounted to 15,638,000 tons which was equivalent to an average 72-day supply. This, of course, comprised coal of a considerable price range; but if an average of six dollars per ton be assumed, this would represent an investment of more than 93 million dollars, with commensurate carrying charges. But this figure applies only to electric utilities; nearly twice this amount was carried in storage by various industries.

Obviously, prudent management requires a reasonable amount of coal storage, just as it does sufficient inventory of any raw material; but under stable labor conditions that would assure a dependable coal supply less storage would be necessary and the carrying charges would be much reduced.

Off to a Good Start

Reviewing events in the power field during the year just ended, one notes a steady increase in energy demand which, judging from recent months, appears headed for new highs during the current year. This was despite two serious interruptions in coal supply and numerous stoppages in production at industrial plants utilizing electrical energy; also despite many delays in delivery of new equipment because of labor troubles and material shortages. If these factors become stabilized the outlook is most promising.

Although the maximum size of steam and electric generating units has not increased over that in some previous years, the number of very large units building or on order is greater. The same applies to steam pressures, but maximum steam temperature has jumped approximately another hundred degrees to 1050 F for some recently projected plants, thus taking advantage of metallurgical lessons learned during the war. For the first time since 1941 a large number of new power stations are in either the design or construction stages. When these efficient plants are in operation the overall fuel consumption per net kilowatt-hour should again decrease below the present average figure of about $1^1/_3$ pounds of coal for the electric generating stations throughout the United States.

The gas turbine advanced appreciably during 1946, both in this country and abroad, but scarcely as a competitor of steam for stationary power. However, two units are now on order in this country for locomotive drive and another for installation in a merchant ship. Also, based on successful and extensive trials of a 6500-horsepower steam-turbine locomotive additional locomotives have been ordered for service in 1947. Both mechanical drive and turbine-electric drive are involved in such applications.

Atomic power has been much in the spotlight, and has advanced to the extent of a pilot plant being laid down for operation at Oak Ridge, Tenn.; and establishment, by the Government, of several research laboratories under private operation for the study of power generation by nuclear energy. The outcome is most likely to be affected by such international agreements as may be accepted and by the economics of the problem. Although tangible results are likely to develop ultimately because of talent and expenditure now behind the effort, no immediate challenge to existing methods of power generation is indicated.

Sustained Performance

The well-known Port Washington Station, as reported in this issue, continues to show an enviable performance which may now be exceeded in one or two instances by individual units operating under very high steam conditions, but scarcely by any other complete station operating on the steam cycle. It is the sustained record for economy and reliability over an eleven-year period for the first unit and more than three years for the second that attests to the excellence of both operation and the original design. The latter has been consistently followed with only slight modifications from the first unit, installed in 1935, to the third which is now nearing completion.

It will be recalled that this station, laid out on the unit principle, operates at a pressure of 1300 psi and a total steam temperature of 825 F. These steam conditions are relatively low compared with those of some stations now operating and others projected, but from the economy angle the lower steam temperature is probably offset by the employment of reheat.

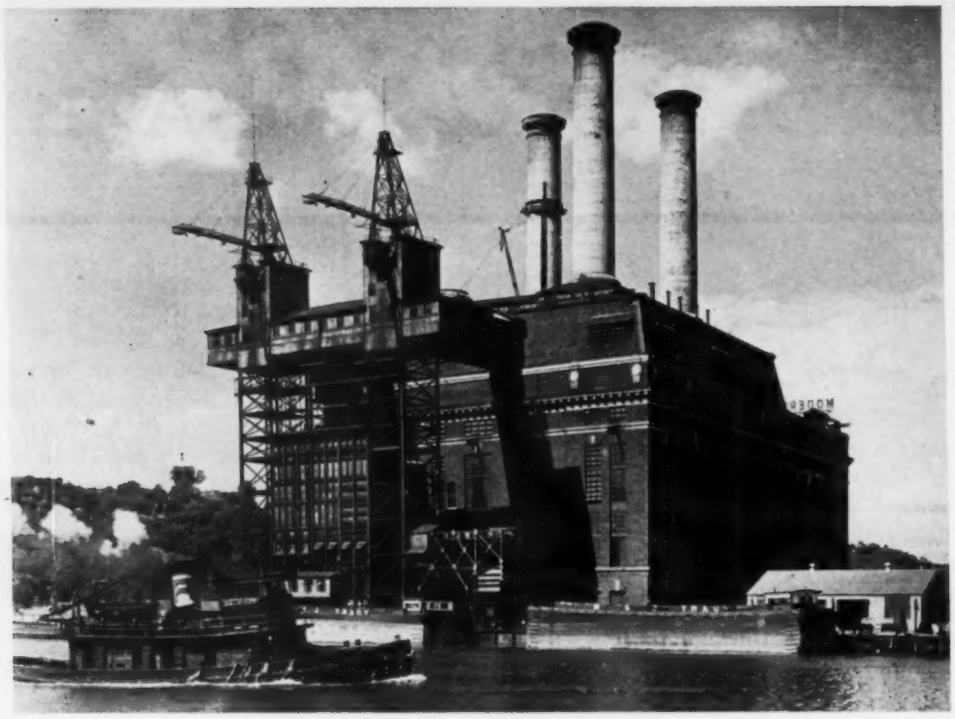


Photo by H. R. Towse

Sherman Creek Station from across the Harlem

Further Topping at SHERMAN CREEK Part I—Steam Generation

By R. T. ROBERTS
Division Engineer,
Consolidated Edison Co. of NewYork*

This second 1,000,000-lb per hr steam generating unit while essentially a duplicate of the first, installed in 1943, nevertheless embodies certain modifications dictated by experience and changed conditions. The present article deals principally with these modifications. A second article by Mr. Knecht, to appear in February, will deal with the new turbine-generator, auxiliaries and heat balance which in some respects differ considerably from the first.

THE first unit of the Consolidated Edison Company's topping program at Sherman Creek Station, New York, went into operation in 1943. This consisted of a 50,000-kw turbine-generator and a 1,000,000-lb per hr boiler operating at 1600 psi steam pressure and 950 F total steam temperature. It was described in COMBUSTION of August and September 1943.

The second unit of this program, designated as No. 100, is now being erected for operation in 1947. When consideration of this boiler was under way, factors entering into the choice of the first boiler still remained; therefore, in order to take advantage of the maximum economies offered by duplication in arrangement and design and the lower investment in spare parts, a Combustion Engineering Company boiler, generally duplicate of the first unit, was ordered. Six 650-hp, 200-psi boilers were removed to provide room for the new installation.

The earlier boiler, No. 90, faces west and it was the intention in 1943 that No. 100 would face east. However, when design was started it was found that a more satisfactory arrangement could be made if the new boiler were turned to face west also. This required a longer steam lead which now is $17^1/_2$ in. O.D. and runs around the boiler to the turbine. As is the case with No. 90,

the Boiler Code covers this piping up to, and including, the turbine throttle valve. In the steam lead, carbon molybdenum forged pipe, A.S.M.E. Specification SA-266, has been used, except that the chemical analysis, tensile strength, yield point, elongation and heat treatment conforms to A.S.M.E. Specification SA-209 Grade T-1.

Three years of operation of boiler No. 90 has been very satisfactory but has brought to light the need for slight changes from the original design in order to meet more nearly the present service conditions. While the original design specified a wide range of fuel, it was found that higher ash and lower fusion coals needed to be considered.

Superheat temperatures were high at times. Therefore, the superheater surface was reduced from 30,712 sq ft to 28,240 sq ft. Three rows of screen tubes were placed in front of the superheater instead of two rows as in boiler No. 90.

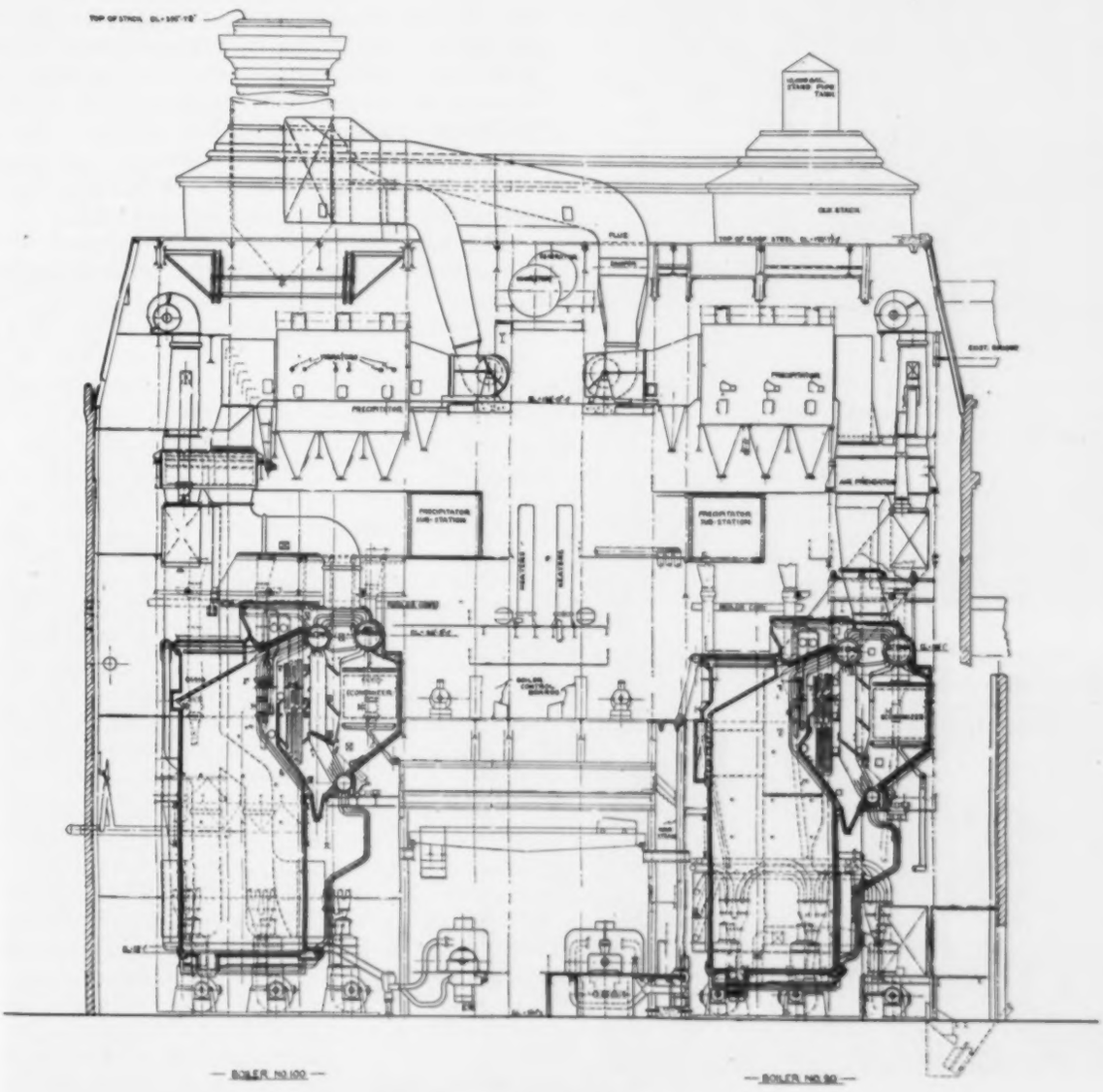
In order to insure against low steam temperature at low loads, provision for four auxiliary burners was made in the front wall of boiler No. 90. These burners have been omitted in the new boiler.

As a precaution against external tube corrosion, furnace tubes have been aluminized for the lower 19 ft.

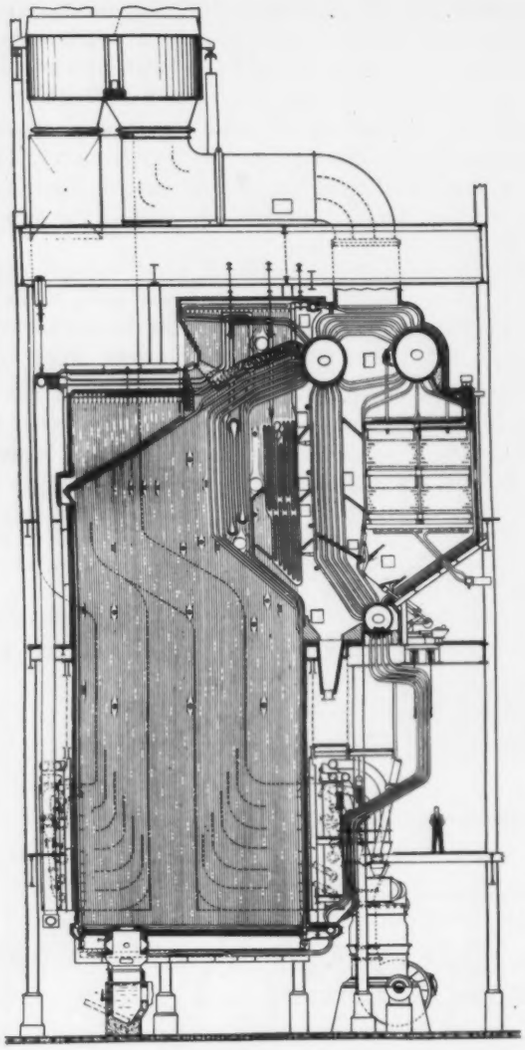
Boiler No. 90 showed a tendency to slag the superheater with certain coals, therefore, a Diamond Power Specialty Company sequential system of soot blowers is being installed in both No. 90 and No. 100. This installation consists of an additional band of side-wall blowers around the furnace at approximately elevation 50 ft 8 in., and three pairs of retracting blowers in the furnace, one under the arch and two at the superheater inlet.

Due to restricted conditions, three water-cooled telescopic blowers are used on the south side, while on the north side, steam-cooled retractable blowers were used. The eighteen air-cooled roof blowers were omitted. Other blowers are generally similar to those on No. 90 and all are coupled into an air-controlled sequence system. This system is so arranged that any group of blowers can be cut out of the sequence and by a simple operation of handles on a control board the entire system can be put in operation, the boiler blown automatically and the system automatically stopped when all points previously selected have been blown.

In order to provide closer superheat regulation, the bypass damper was made with a pair of auxiliary recipro-



Cross-section through boiler room



Above—Section through million-pound-per-hour high-pressure steam-generating unit

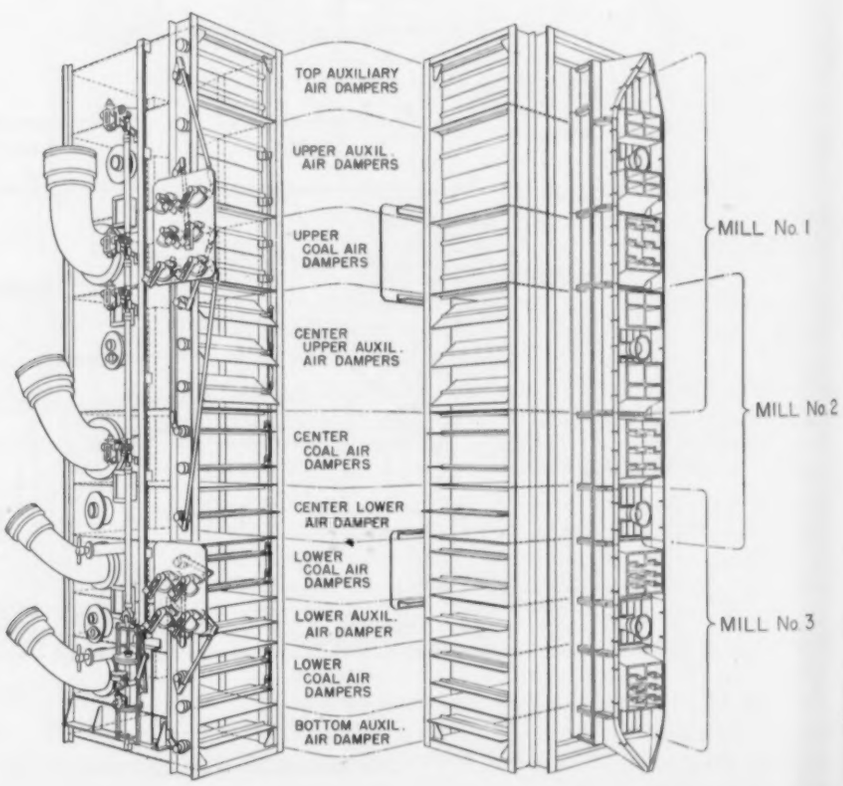
cating leaves. As the main damper opens, due to impulses created by high steam temperature, the auxiliary dampers approach each other, partially closing off passage of gas through the lower portion of the superheater. A greater amount of gas then passes only the upper portion of the superheater and directly to the economizer through the dead pass; thus greatly reducing the effective gas touched surface of the superheater.

Due to the Company's established policy of acid washing the units at definite scheduled intervals, additional vent, drain and blowoff connections were installed on the new boiler so as to reduce the time required for filling and emptying.

It is the intention, at some time, to make the automatic boiler regulation more closely follow the turbine load, and to this end, response to load changes is being speeded up. The bowl mills of No. 90 were changed so that the bowl is now built more shallow than previously and with a flat bottom. This feature alone has cut response time in half. While the rating of the No. 90 and No. 100 mills is nominally the same, the worm gear has been increased in size in the latter to reduce maintenance, and forced-feed lubrication has been added. The exhauster wheels are 2 in. larger on the new mills and are equipped with a set of auxiliary vanes called whizzers. The whizzer vanes are of smaller diameter than the main wheel and are located at the exhauster inlet. The coarser coal passes through the whizzer and is discharged at a much lower velocity, with as much as 40 to 50 per cent reduction in wheel erosion. The mills are also arranged with center feed and a center auxiliary air supply, thus greatly eliminating trouble with sticking in the feed spouts when handling extremely wet coals.

The flues will generally duplicate those of No. 90. No recirculating fans will be installed but, instead, a by-

Right—Sketch showing two elevations of burner boxes with details of the vertically adjustable features



pass duct will be installed around the air preheaters between the forced-draft fan discharge and the secondary air duct, in order to reduce corrosion on the preheater elements during low load periods.

The Ljungstrom air preheaters will have at the top (cold end) two layers of preheater surface, 6 in. and 4 in. in depth, respectively, of Cor-ten steel, widely spaced, and placed in baskets for quick removal and replacement in case of fouling. By increasing the spacing of the cold-end elements it has been found easier to keep them clean. In case of fouling, fouled baskets are removed and clean ones installed. The fouled baskets can then be washed and stored for future emergency use.

Each heater will be equipped with a single-nozzle, motor-driven reciprocating soot blower. Tests with the No. 90 preheaters have shown that no fouling occurs if the blowers are operated for a half hour during each watch. Blowing is done six days per week at 300 psi and at 400 psi on the seventh day. These heaters have operated for ten months without any increase in draft loss. No other water washing will be used on the air heater elements.

The ash-handling system was extended to serve the new boiler. As the need for stoker ash storage has become less, another bay of the ash pocket has been utilized for fly-ash storage. One of the existing receivers and bag filters was moved to discharge into the new bay, and a dustless unloader and belt conveyor for ash, similar to those existing, has been placed in this bay. All three dustless unloaders discharge to reversible belts so that the ash, conditioned to be dust-free, can be unloaded either outboard to barges or inboard to trucks.

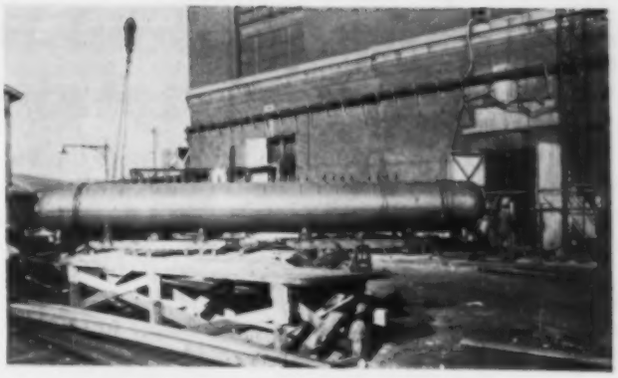
Fans Turbine-Driven

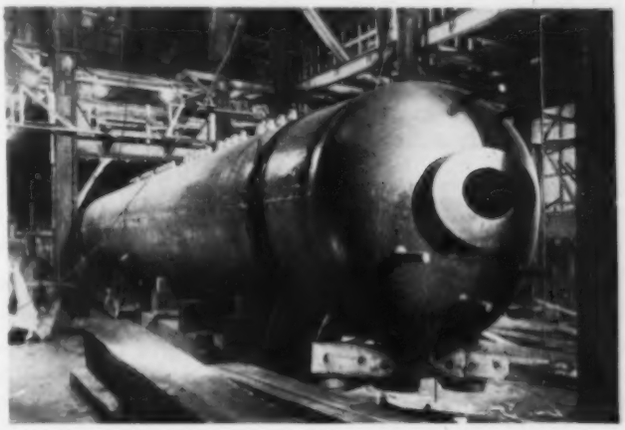
The induced-draft fans are American Blower Company, Sirocco S-30 type, designed to handle 225,000 cfm of gas at 320 F and 15 in. static pressure. Each pair of fans is driven by a single impulse turbine through a direct-connected reduction gear of the double-helical type with double-ended drive shaft. The turbine speed is 4910 rpm at maximum condition, ratio 8.05. Steam to the throttle is 200 psi abs at 485 F, exhausting at 18 psi abs.

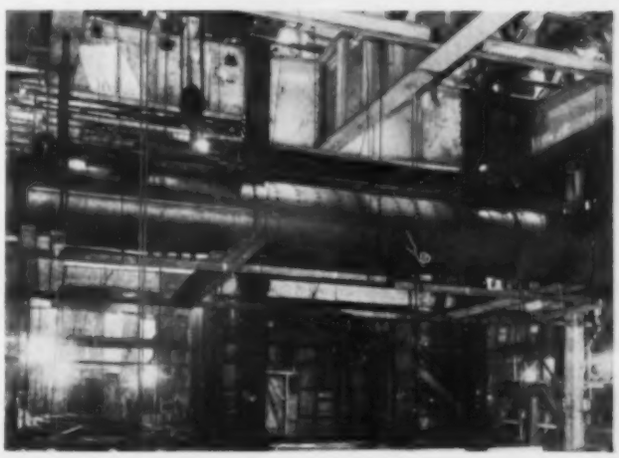
The forced-draft fans are also of American Blower Company type, each designed for 156,000 cfm at 15 in. static pressure. In the case of No. 100 boiler, air temperature is specified at 120 F instead of 80 F as in the case of No. 90 boiler. These fans are also driven by a single turbine of the impulse type with double-helical reduction gear employing G. E. quill-type drive shafts. Turbine speed is 5640 rpm at maximum condition, ratio 4.6. Flexible couplings are special G. E. type. Steam to the throttle is 200 psi abs at 485 F, exhausting at 18 psi abs.

The coal bunker and existing Redler coal conveyor were altered so that the latter would take coal from more bunker openings to serve the three additional mills. Scales were omitted in this installation. Downtakes are made with continuously expanding sections so that handling of wet coal can be done with less sticking.

This boiler, as well as No. 90, is equipped with a control panel located in the boiler room basement upon which the temperature of the mill air is indicated, and from which the mill air temperature is controlled. Mill air temperature also registers and is recorded in the control room.







Sequential views of drum raising

The control room is designed to accommodate a similar and opposite-hand arrangement of the control benchboard and vertical panel, such as was provided for No. 90. Combustion and feedwater controls generally duplicate the existing installation.

The sight gage system of No. 90 transmits the water level optically from both ends of the drum to the control board. This system has been amplified by a Yarway remote level indicator on Boiler No. 100.

In lighting off No. 90 boiler, it was found that the stack draft caused too high a suction in the furnace, irrespective of fan speed. A manually controlled damper at the outlet on the induced-draft fans has been employed for draft control, but its position is such as to be inconvenient for operation. Therefore, both No. 90 and No. 100 will be equipped with power-driven dampers, the controls of which are in the control room.

Vertically Adjustable Burners Control Exit Gas Temperature

The new boiler has four burners per corner instead of three as in the earlier unit. To attain the additional burner, the piping from the mill serving the bottom burner has been subdivided. This subdivision was made in order to attain a more intimate mixing of coal and air and lessen the tendency toward wall corrosion. The two bottom burners are adjustable vertically by hand wheels and the two top burners are adjustable vertically through a pneumatic cylinder. This vertical adjustment of the burners affords control of exit gas temperature and thus assists in maintaining constant superheat. All controls are local at each corner of the boiler.

The burners of No. 90 boiler were equipped with automatic gas ignition torches for lighting off and warming up the unit. In order that the tremendous gas consumption of the station would not be increased by another gas-ignited boiler, it was decided to utilize the oil storage, heating and pumping facilities of the station for ignition of the new boiler, using either oil or gas tar. Eight steam atomizing ignition torches are capable of heating up the boiler in a minimum of time to the point where the turbine can be rolled and the boiler fired with pulverized coal. In addition, sixteen mechanical atomizing burners are provided, so that in case of coal shortage, the full boiler evaporation can be obtained. In this event, the ignition is accomplished with the steam atomized torches, which are then replaced, one by one, with mechanical atomizing burners. This substitution can be made while the unit is operating, without change in load.

The oil supply valve is incorporated in the interlock system and closes with loss of either forced- or induced-draft fan pressure, in the same manner as the mills and feeders shut down when firing with coal.

The boiler takes its water from the existing system. Blowdown is into the existing blowdown tanks which were installed with boiler No. 90. Other boiler plant features remain practically the same as in the first installation.

The availability of first boiler in 1945 was 93 per cent. With the changes noted, it is felt that even greater reliability is to be expected from the new boiler. It is also felt that more ease of operation and less maintenance will be attained.

PRINCIPAL BOILER PLANT EQUIPMENT IN SHERMAN CREEK TOPPING UNIT NO. 100

Steam Generating Unit

One *Combustion Engineering Company, Inc.*, bent-tube boiler, bifurcated, bare-tube water walls, *Elesco* pendant-type superheater, *Elesco* economizer, *Ljungstrom* air heaters. Steam generating capacity 1,000,000 lb per hr, 1600 psi and 950 F; boiler 14,100 sq ft; water walls 10,995 sq ft; superheater 28,200 sq ft; economizer 33,960 sq ft; air heaters each 124,800 sq ft; furnace volume 53,700 cu ft; furnace heat liberation 21,900 Btu per cu ft at 1,000,000 lb tangentially fired, 4 burners per corner with oil ignition torches; 3 *Raymond* bowl-type mills each driven by a 300-hp *G. E.* 900 rpm, 3-phase, 60-cycle, 2300-v motor.

Precipitator

One *Cottrell* precipitator, manufactured by *Research Corporation* and designed for 95 per cent removal when handling 460,000 cfm gas at 340 F; three sections long, steel plate electrodes with 4 electrical sets operating at half wave on the first two sections; either full wave or half wave on last section.

Induced-Draft Fans

Two *American Blower Corporation* No. 12 DI 1/2 DW *Sirocco* S-30; designed for 225,000 cfm of 320 F gas at 15 in. H_2O static pressure at 598 rpm.

Induced-Draft-Fan Drives

Two fans are driven by a single *Westinghouse* turbine with double-ended driving shaft; turbine rating 1700 hp at 4700 rpm with 185-psi, 485-F steam, exhausting at 3 psi noncondensing; gear reduction double helical gear and pinion—ratio 8.06.

Forced-Draft Fans

Two *American Blower Corporation* No. 10 DI DW high-speed backward inclined blades; each designed for 156,000 cfm of 120 F air at 15 in. H_2O static pressure at 1227 rpm.

Forced-Draft-Fan Drives

Two fans driven by a single *G. E.* turbine with double-ended driving shaft; turbine rating 946 hp at 5760 rpm with 180-psi, 485-F steam and exhausting at 3 psi; noncondensing, impulse type; gear ratio 4.7.

Soot Blowers

Diamond Power Specialty Corporation system consisting of retracting wall blowers, telescopic blowers at arch, superheater inlet and superheater bank and rotating elements in convection surface and economizer, arranged to steam blow sequentially as controlled by air from a control panel.

Fly Ash Handling

Extension to existing *United Conveyor* pneumatic system with loading points at boiler, precipitator, flues and stack, discharging to ash pockets on wharf. Existing system consists of duplicate cyclone receivers and bag filters (1 set a spare), powered by *G. E.* 75-hp, 1775-rpm, 208-v, 3-phase, 60-cycle motors; remote automatic and manual control from separate control panel at boiler; capacity 7 1/2 tons of ash per hour.

Fly-Ash Conditioner

One new *United Conveyor* rotary ash conditioner installed in parallel with the existing two below the ash pockets; capacity of each 25 tons of dry ash per hour.

Conditioned Fly-Ash Conveyors

One new *Stephens Adamson Mfg. Co.* 30-in. reversing belt conveyor installed in parallel with the existing two and arranged to move outward and discharge to scows or move inboard and discharge to trucks; driven by 2-hp, 116-rpm, 3-phase, 60-cycle, 208-v totally enclosed dust-tight, weatherproof motors; capacity of each 50 tons per hour.

Coal Distributing Conveyor

One existing 15-in. side-pull Redler conveyor by *Stephens Adamson Mfg. Co.*, 167 ft long × 15 ft 4 in. wide centers; rearranged to load at six additional points and discharge to three new and three existing mills; capacity 20 tons per hour; powered by two 7 1/2-hp *Westinghouse* geared motors.

Combustion Control

Republic Flow Meter type arranged to regulate the induced- and forced-draft fan turbine speeds and coal feed to maintain desired steam pressure.

Feedwater Control

Bailey Meter Company three-element control on steam flow; water flow and water level varies speed of boiler feed pumps.

Control Bench Board and Panel

Light gray formica covered plywood on structural steelwork fabricated by *Falstrom Co.* Plywood fabrication, formica application and shop assembly by *Schvetz & Hadeler.*

Blowdown System

Into existing *Babcock & Wilcox Co.* system consisting of one high- and one low-pressure flash tank in series designed to flash 150,000 lb of blowdown per hour.

Chemical Feed Pumps

Two *Proportioneer* duplex high-pressure chemical feed pumps (1 spare) for phosphate and caustic; capacity range per cylinder, 0.03 to 0.3 gpm at 2200 psi.

Feedwater Treatment

Makeup from existing low-pressure condensate system or from existing *Permutil* sodium-hydrogen *Zeo-Karb* softening system designed to soften 50,000 lb per hr of Croton water.

Electric Energy Production in the United States

The total installed capacity of utility and industrial plants, at the end of 1945 was 62,900,000 kw. Of this, steam accounted for 72 per cent, hydro 25.3 per cent and internal-combustion engines 2.7 per cent. There were 706 steam plants among the private utilities and 351 under public ownership. Of the total electric energy used during the year by manufacturing industries, 68.9 per cent was purchased and 31.1 per cent privately generated.

EACH year about this time the Federal Power Commission issues a comprehensive report covering the installed capacity of generating plants and the production of electricity by both utilities and industrial plants throughout the United States, broken down into the sources of energy, class of ownership, type of industry, geographical distribution, etc. Comparisons are made over successive years. The following reviews some of the statistics presented in the report just issued.

Data presented on utility plants are exclusive of electric railways or electrified railroads, and the New York City Transit System, all of which combined amount to 1.1 per cent of the total produced for public use. Also excluded in this group is power supplied to utility systems by large industrial plants. The statistics on industrial plants cover establishments having capacities of 100 kw or more. No information is given on power generated in office buildings, hotels, hospitals, etc.

Installed Capacity

The total installed capacity of utility and manufacturing plants of more than 100 kw in the United States at the end of 1945 amounted to approximately 62,900,000 kw of which over 50.1 million kilowatts, or 79.7 per cent was in utility plants and 12.8 million, or 20.3 per cent, was in industrial plants.

In terms of kilowatts capacity, there was only a small change of approximately one per cent in the relative position of utility and non-utility producers during the period from 1939 through 1945, although the total combined capacity increased from 49.4 million to 62.9 million kilowatts, an increase of 27.2 per cent.

Of the 50,110,928 kw installed in utility plants, 34,112,603 represent steam capacity, 14,911,617 kw hydro capacity and 1,086,708 kw internal-combustion engines. In other words, steam accounted for 68.2 per cent, hydro 29.7 per cent and internal-combustion engines 2.1 per cent of this total. However, of the combined utility and non-utility capacity, steam represented 72 per cent, hydro 25.3 per cent and internal-combustion engines 2.7 per cent.

The successive increases in utility capacity over the past 25 yr were as follows:

Year	Kilowatts	Year	Kilowatts
1920	12,713,608	1933	34,586,688
1921	13,518,734	1934	34,118,741
1922	14,191,922	1935	34,435,768
1923	15,642,537	1936	35,081,569
1924	17,680,743	1937	35,620,011
1925	21,472,077	1938	37,492,095
1926	23,386,194	1939	38,862,716
1927	25,079,025	1940	39,926,881
1928	27,804,576	1941	42,405,436
1929	29,839,459	1942	45,052,950
1930	32,384,363	1943	47,950,767
1931	33,698,256	1944	49,189,072
1932	34,386,739	1945	50,110,928

From this it will be seen that the capacity increased four-fold during this period.

The total number of plants generating power for public use in 1945 was 3886 (representing 1594 owners) of which 2400 were privately owned utility plants and 1486 publicly owned. The privately owned utility plants accounted for approximately 80 per cent of the installed capacity and 81.3 per cent of the output. Of these, 706 were steam plants, 1162 hydro and 532 internal-combustion engines. Publicly owned plants, including Federal, municipal and those owned by cooperatives and power districts, consisted of 351 steam stations of slightly over 3 million kilowatts capacity and 792 internal-combustion engine plants totaling 722,139 kilowatts.

Energy Production

In 1945 the total production of electric energy for both public and private use in the United States was 271.3 billion kilowatt-hours. Of this total, electric utilities produced 222.5 billion kilowatt-hours or 82 per cent and non-utility plants generated 48.8 billion kilowatt-hours, or 18 per cent. Such figures for the years 1939 to 1945, inclusive, are given in Table 1 from which it will be noted that the high year was 1944.

Total generation during 1945 was greatest in New York State, with over 25 billion kilowatt-hours; Pennsylvania was next with nearly 23 billion kilowatt-hours and Ohio third with 18 billion kilowatt-hours.

TABLE 1—ELECTRIC ENERGY GENERATED IN THE UNITED STATES 1939–1945

Source of Supply	Kilowatt-Hours in Billions							Per Cent Total Kilowatt-Hours						
	1939	1940	1941	1942	1943	1944	1945	1939	1940	1941	1942	1943	1944	1945
Electric Utilities*	127.6	141.8	164.8	186.0	217.7	228.2	222.5	79.1	78.8	79.1	79.8	81.4	81.6	82.0
Non-Utility Producers†	33.7	38.1	43.5	47.2	49.8	51.3	48.8	20.9	21.2	20.9	20.2	18.6	18.4	18.0
All Producers	161.3	179.9	208.3	233.2	267.5	279.5	271.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Data for railroads and railways are included in non-utility producers.
† Does not include production of certain establishments, generally those having installed generating capacity of less than 100 kilowatts. The production of such establishments in the aggregate does not exceed one and one-half per cent of total non-utility production.

The 1945 annual average plant factor (ratio of actual output to installed capacity operating at 100 per cent over the year) for utility plants was 51.2 per cent. This was slightly under the 53.5 per cent reached in 1943–1944. That for fuel-burning plants during 1945 was 46.6 per cent and for hydro plants 61.9 per cent.

Energy Used in Manufacturing

During 1945 the use of electric energy by manufacturing and extracting industries amounted to 143.2 billion kilowatt-hours, or 52.8 per cent of the total produced by utilities and non-utility plants. Of this total 68.9 per cent, or 102.3 billion kilowatt-hours came from purchases, and 31.1 per cent, or 46.2 billion kilowatt-hours, from the manufacturers' own power plants. In 1939 only 61.7 per cent was purchased and 38.3 per cent was privately generated. Moreover, in 1945 the total industrial use of electric energy was 1.8 times that of 1939, although in 1944, when war production was at its peak, this figure reached 100.8 per cent.

Electric energy requirements by the major industrial groups in 1945 were as follows:

Manufacturing Industries	1000 Kilowatts	Manufacturing Industries	1000 Kilowatts
Chemicals	24,589,745	Automobiles	3,774,197
Iron and steel	21,701,857	Electrical machinery	3,384,614
Non-ferrous metals	14,911,831	Rubber	2,683,214
Paper	11,444,689	Lumber	1,464,106
Food	8,987,885	Printing	1,161,338
Textiles	8,435,646	Furniture	881,743
Petroleum and coal	6,538,861	Miscellaneous	852,107
Transportation equipment	6,417,551	Apparel	661,002
Stone, clay and glass	5,400,486	Leather	578,848
Machinery	5,136,479	Tobacco	176,939

The first three of these industries, namely chemicals, iron and steel, and non-ferrous metals, together, accounted for 42.8 per cent of the total used. Furthermore, approximately two-tenths of one per cent of the total number of establishments reporting used slightly over one-half the total electric energy used by the manufacturing and extracting industries.

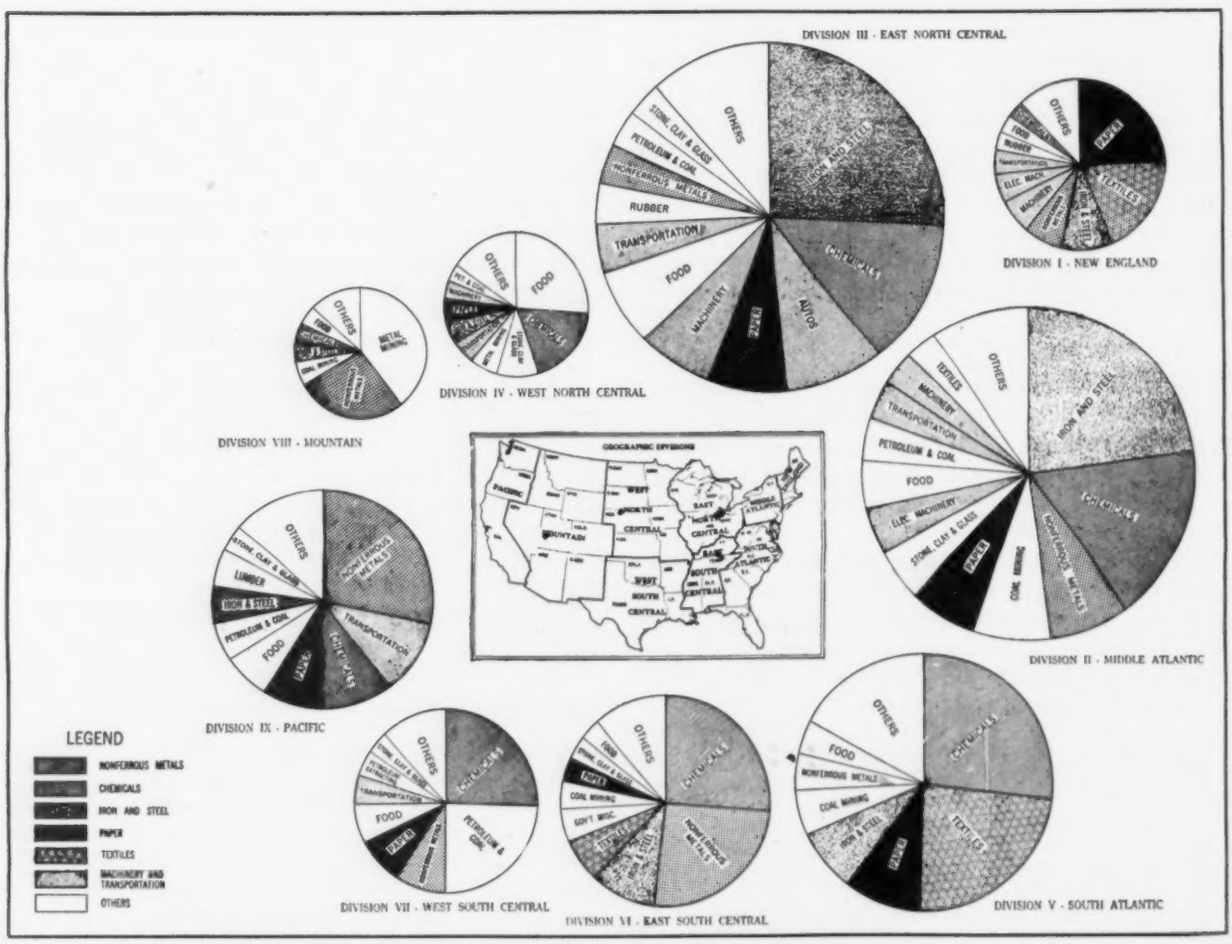
In the extracting industries, coal mining used over 5 billion kilowatt-hours, metal mining nearly $3^1/_2$ billion, non-metallic mining $1^1/_2$ billion and petroleum and natural gas close to a billion kilowatt-hours. Shipbuilding accounted for over a billion kilowatt hours and government manufacturing plants $1^1/_2$ billion kilowatt-hours.

Based on reports covering more than 60 per cent of the energy used by industrial plants, 7.74 per cent of the energy was employed for lighting; 63.24 per cent for motors; 13.13 per cent for electrolytic cells; 13.67 per cent for electric furnaces; and 2.22 per cent for all other uses.

The average annual load factors, in per cent, for electricity purchased and generated during the years 1939 through 1945 are shown in the following tabulation:

	1939	1940	1941	1942	1943	1944	1945
Purchased	40	42	46	48	53	54	50
Generated	51	55	58	59	60	60	56

The complete report in two sections (S-46 and S-48) which covers 67 pages, including numerous charts and tables is obtainable from the Federal Power Commission, Washington, D. C., for 75 cents.



Use of electric energy by major industries in nine geographic regions

1945–1946 Performance at PORT WASHINGTON

Through courtesy of the Wisconsin Electric Power Company we are again privileged to report the yearly performance and experience of Port Washington Station which, it will be recalled, for a number of years had the distinction of being the most efficient steam-electric generating station. The latest figures covering the two distinct units show average station heat rates during 1946 of 10,538 and 10,696 Btu per kwhr. A third unit comprising a 690,000-lb per hr boiler and 80,000-kw turbine-generator is now being installed. This is a strictly unit-type plant and no main steam or feedwater tie lines exist.

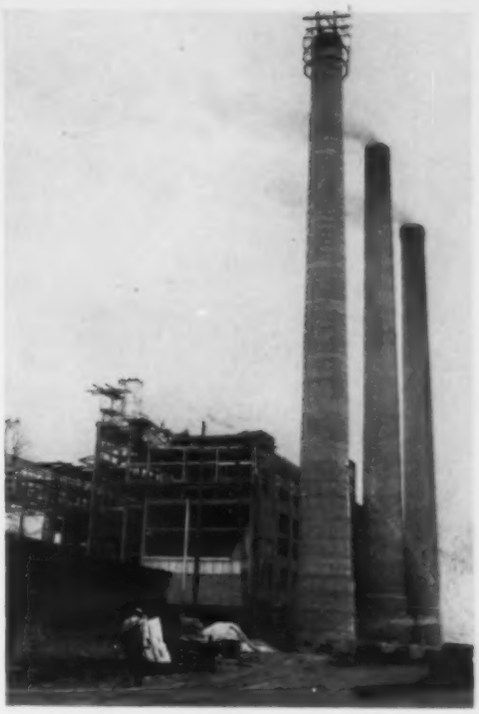


Fig. 1—Construction view of third unit

THE FIRST unit of Port Washington (PW1) has completed its eleventh year of operation and the second unit (PW2) its third year, and close to 90 per cent operation continues to be averaged by the two units. The station heat rate continues at close to previous levels of about 10,700 and 10,500 Btu per net kilowatt-hour output for the first and second units, respectively. Several months operation with a number of rows of blading removed from both turbines caused temporary high heat consumption. This will be noted by reference to the curves in Fig. 2.

Table 1 lists the outages, their duration, and reasons with reference to both units. From this it will be observed that blading trouble was responsible for more than 1300 hr of outage. Random cracking of turbine blades near the inlet of the low-pressure section of turbine No. 1 and near the high-pressure section exhaust of turbine No. 2 constituted the major threat to reliability and economy during the previously unreported years of 1945 and 1946. In all, 118 blade rows of 20 per cent nickel, 8 per cent chromium cast-in blading sections in these zones have been changed, the majority to 13 per cent chrome-steel

TABLE 1—OPERATING PERIODS AND REASONS FOR OUTAGES—1945 and 1946

Period No.	Started	Finished	Hr. Run	Kwhr Generated, Millions	Outage Hr	Outage Reason
				UNIT 1		
65	12/27/44*	3/15/45	1885.92	132.147	78.87	General boiler inspection
66	3/18/45	11/ 2/45	5499.48	317.374	1044.75	General boiler inspection. Install new soot blowers at new locations. Install hydraulic ash removal system; new furnace bottom. Install new blading last 7 stages of intermediate section, and first 6 stages of double flow low pressure section
67	12/16/45	12/28/45	298.05	17.286	17.93	Inspected No. 1 inlet valve of turbine
68	12/29/45	6/ 8/46	3870.33	216.579	181.67	Inspected and repaired inlet valves and power piston
69	6/16/46	7/ 1/46	352.05	19.952	1263.22	Replaced failed coil turns and reinsulated others, generator stator. Rerolling rear water wall tubes, boiler. Forced Outage
70	8/22/46	12/26/46†	3028.73	194.515	....	.....
Total	12/27/45	12/26/46	14934.56	887.853	2586.44	.....
Total	11/22/35	12/26/46	86330.34	4972.120	10941.66	.....
				UNIT 2		
13	12/27/44‡	3/ 3/45	1585.50	107.580	88.12	Removed last 4 rows of blading in intermediate section before L. P. section. Delayed forced outage
14	3/ 6/45	4/ 9/45	813.63	38.661	8.75	Electrical auxiliary supply switch failure. Forced outage
15	4/ 9/45	6/23/45	1769.58	81.520	810.19	Replaced last 7 rows of blades, spindle and cylinder in intermediate section, and first 3 rows each side of L. P. spindle and first 6 rows each side of L. P. casing
16	7/26/45	1/ 4/46	1949.72	103.342	45.38	Internal soaking radiant superheater
17	1/ 6/46	4/15/46	1635.95	102.310	421.12	Installed new type blading rows 70 and 77, L. P. cylinder
18	4/ 2/46	7/21/46	2643.43	168.193	0.87	System trouble, storm. Forced outage
19	7/21/46	9/25/46	1588.98	110.516	92.17	Repaired leaky welds, radiant reheater. Installed new type seats, boiler safety valves
20	9/26/46	12/26/46†	2117.90	144.561	....	.....
Total	12/27/45	12/26/46	14104.69	856.683	1466.60	.....
Total	10/27/45	12/26/46	25267.54	1599.706	2489.99	.....

* This operating period started 12/17/44.
† Still in operation.
‡ This operating period started 7/11/44.

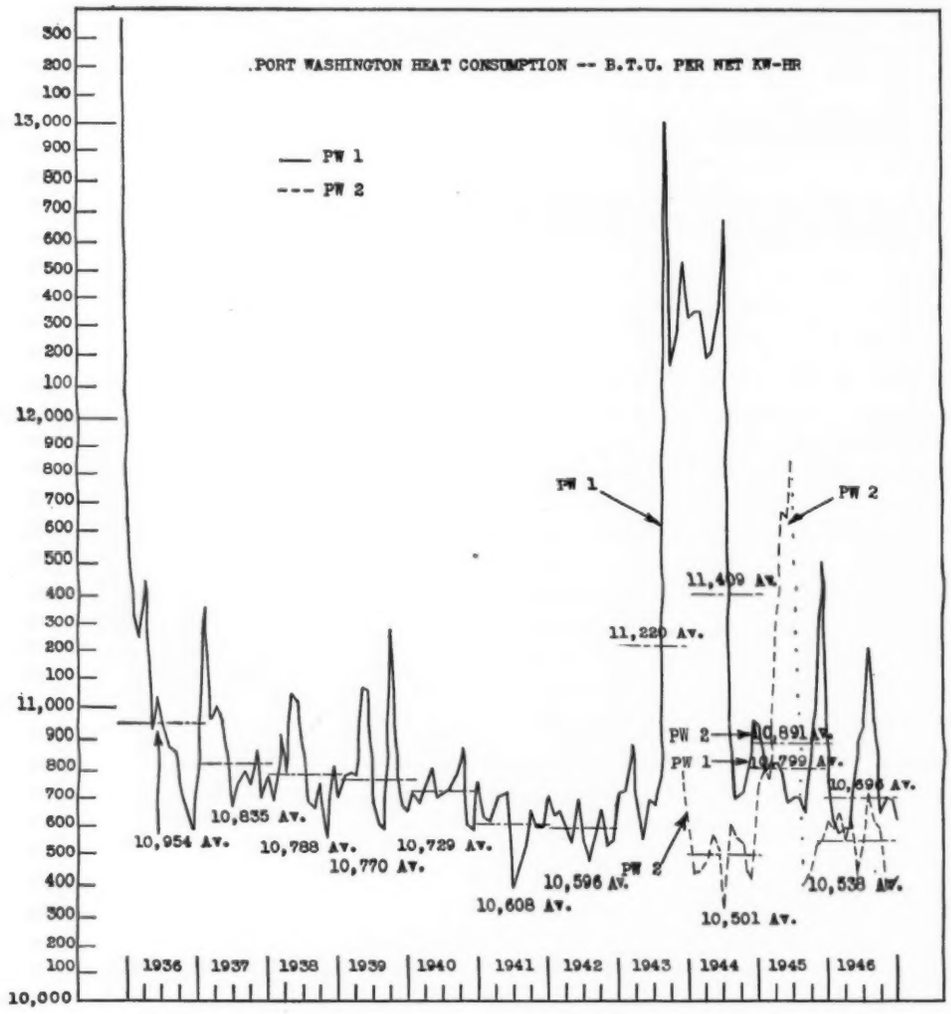


Fig. 2—Heat consumption rates, Btu per net kilowatt-hour

TABLE 2—USE AND AVAILABILITY DATA

UNIT 1

	1945			10 Year Average			1946			11 Year Average		
	Boiler	Turbine	Plant	Boiler	Turbine	Plant	Boiler	Turbine	Plant	Boiler	Turbine	Plant
Use factor Service hours / Period hours	87.2	87.2	87.2	89.2	89.1	89.1	83.3	83.3	83.3	88.7	88.6	88.6
Hourly output capacity factor Av. hourly output / Rated hourly output	69.3	75.9	75.9	65.0	71.9	71.9	68.5	74.3	74.3	65.3	72.1	72.1
Annual output capacity Annual output / Annual rated output	60.4	66.2	66.2	58.0	64.1	64.1	57.1	61.9	61.9	57.9	63.9	63.9
Annual demand factor Demand hours / Annual hours	91.5	95.7	100	92.9	96.7	99.0	83.8	85.6	100	92.1	95.7	99.1
Demand availability Service hours / Demand hours	95.3	91.1	87.2	96.5	92.7	90.5	99.4	97.3	83.3	96.8	93.1	89.8
Annual availability factor 100 − Repair hours / Annual hours	87.6	88.1	87.2	94.2	92.9	90.1	95.9	97.7	83.3	94.4	93.3	89.5

UNIT 2

	1945			26 Months			1946			38 Months		
Use factor Service hours / Period hours	89.7	89.6	89.6	89.1	89.8	89.8	93.6	93.6	93.6	90.5	91.0	91.0
Hourly output capacity factor Av. hourly output / Rated hourly output	70.4	73.4	73.4	74.9	80.6	80.6	75.8	82.1	82.1	75.2	81.1	81.1
Annual output capacity Annual output / Annual rated output	63.5	65.8	65.8	67.0	72.4	72.4	70.9	76.9	76.9	68.3	73.8	73.8
Annual demand factor Demand hours / Annual hours	91.6	98.0	100	92.1	97.2	100	95.2	98.4	100	93.1	97.6	100
Demand availability Service hours / Demand hours	98.0	91.5	89.6	96.8	92.4	89.8	98.4	95.1	93.6	97.3	93.3	91.0
Annual availability factor 100 − Repair hours / Annual hours	98.1	89.7	89.6	94.7	90.2	89.8	97.3	95.2	93.6	95.5	91.8	91.0

TABLE 3—OUTPUT AND HEAT CONSUMPTION DATA

Year	Month	Output, Kwhr			Heat Consumption, Btu per Kwhr		
		Gross	Auxiliary	Net	Gross	Auxiliary	Net
			UNIT 1				
1946	Jan.	40,116,000	2,191,217	37,924,783	10,033	580	10,613
	Feb.	36,096,000	1,935,935	34,160,065	10,009	568	10,577
	Mar.	39,671,000	2,131,041	37,539,959	10,026	569	10,595
	Apr.	40,692,000	2,178,988	38,513,012	10,023	567	10,590
	May	45,013,000	2,420,924	42,592,076	10,321	586	10,907
	June	31,138,000	1,783,762	29,354,238	10,317	627	10,944
	July	6,595,000	475,480	6,119,520	10,397	808	11,205
	Aug.	5,045,000	390,669	4,654,301	10,127	850	10,977
	Sept.	45,045,000	2,465,602	42,579,398	10,069	583	10,652
	Oct.	49,049,000	2,641,890	46,407,110	10,135	577	10,711
	Nov.	45,717,000	2,494,610	43,222,390	10,099	583	10,682
	Dec.	49,659,000	2,673,641	46,985,359	10,042	572	10,614
12 Months		433,836,000	23,783,789	410,052,211	10,110	586	10,696
1936–1946, 132 months		4,934,521,000	261,816,206	4,672,704,794	10,273	576	10,849
1935–1946, 135 months		4,975,688,000	264,576,506	4,711,111,494	10,282	578	10,860
			UNIT 2				
1946	Jan.	44,589,000	2,378,985	42,210,105	10,109	565	10,584
	Feb.	41,689,000	2,208,690	39,480,310	10,086	564	10,650
	Mar.	29,287,000	1,612,960	27,674,040	9,976	581	10,557
	Apr.	34,723,000	1,859,810	32,863,190	10,064	569	10,633
	May	48,454,000	2,523,130	45,930,870	9,890	544	10,434
	June	44,847,000	2,381,971	42,465,029	9,960	559	10,519
	July	49,572,000	2,663,420	46,908,580	10,133	575	10,708
	Aug.	54,286,000	2,935,980	51,350,020	10,042	575	10,617
	Sept.	46,827,000	2,538,120	44,288,880	10,013	574	10,587
	Oct.	44,710,000	2,406,350	42,303,650	9,830	560	10,390
	Nov.	48,244,000	2,623,205	45,620,795	9,827	565	10,392
	Dec.	51,607,000	2,753,370	48,853,630	9,867	556	10,423
12 Months		538,835,000	28,885,991	509,949,009	9,973	565	10,538
1943–1946, 38 months		1,639,696,000	86,286,706	1,553,409,294	10,072	559	10,631

machined blades. Further minor changes are scheduled which will total 38 per cent of the blade rows in the two units.

Boiler Availability

As will be noted from Table 2, boiler availability has continued high, averaging 95.9 per cent for No. 1 and 97.3 per cent for No. 2 during the year 1946. The eleven-year average has been about 95 per cent.

There has been no suggestion of previously reported corrosion trouble since 1939. Neither boiler has been turbined nor acid-cleaned and the drums are merely hose flushed.

TABLE 4—OCT. 1946 AV. DAILY BOILER-WATER ANALYSIS, PPM.

UNIT 2	
Pht. Alkalinity, NaOH	4.0
Phosphate, Na_2HPO_4	17.0
Sulphate, Na_2SO_4	4.0
Silicate, SiO_2	1.3
Dissolved solids	25.3
Suspended solids	4.0
Total solids	29.3

In order to obtain maximum possible turbine efficiency, new highs of steam cleanliness have been obtained by limiting the boiler water concentrations, especially the silica, to low values. This is indicated in Table 4 which shows an average during October 1946 of 29.3 ppm total solids in the water of boiler No. 2. Boiler water silica of 0.7 ppm has been attained for long periods, although this is exceeded in the month covered by Table 4.

Reheater Experience

Reheater operation continues an incident to boiler-unit operation because major steam-temperature regulation is inherent to the design. Reheater steam control thus becomes practically automatic, like that of another stage heater, for instance.

Six per cent of the reheater surface of boiler No. 1 was changed in 1946 when convenient, by welding new straight lengths of 18–8 tubing into the present hairpin elements where they had deteriorated. "Fire-cracks," due to greater expansion of the fire-side than the wall-side of these high-alloy tubes having 45 per cent more resistance to circumferential heat flow and 40 per cent more thermal expansion, caused minute leaks upon test after $10^1/_2$ yr. operation.

Reheat has afforded and apparently will continue to afford about 5 per cent higher efficiency than non-reheat cycles of comparable steam temperatures. By thus allowing higher economy at lower steam temperatures it has fortunately assisted avoidance of piping graphitization troubles. Moreover, reheat has permitted 1930 design to have comparable efficiency and reliability with usual 1945 designs.

High-Pressure Heater Tube Joints

High-pressure heater steel-tube joint leaks of the second unit have proved more troublesome than those of the first unit, apparently because of a poorer tube-end expansion method of the small $^1/_2$-in. ID 10-gage tubes than those used for the first unit. Seal welding of the second unit tube ends did not develop to be corrective of joint leakage. Leaks develop periodically after many months of service, and in a week or two become large unless detected early and stopped by high quality seal welds. Apparently the 1500-psi condensate with zero suspended solids penetrates microscopic fissures and erodes them to rapidly increasing size.

Generator Insulation

The 22,000-volt generator of the first unit developed phase-to-phase short-circuit where two of its stator connector leads were spaced closely, with a small air gap in which corona has been previously experienced. Differential relay protection removed it from service at a load of 20,000 kw on July 1, 1946. As a consequence, $7^1/_2$ weeks repair of stator connector leads insulation were required. A complete set of stator coils insulated with more mica and less varnished cambric has been ordered to replace the present stator winding when convenient to take the generator out of service.

Pulverized Coal Storage System

Storage capacity of its pulverized-coal bin has been extensively used practically every work day since the second unit was initially started, for its fuel burning capacity is about ten per cent in excess of its milling capacity and it normally carries full load from 7 a.m. to midnight. Fig. 3 shows 4-ft and 10-ft pulverized coal level reductions when units 1 and 2, respectively, carried 80,000 kw for 17 hr on a day while one of the four mills

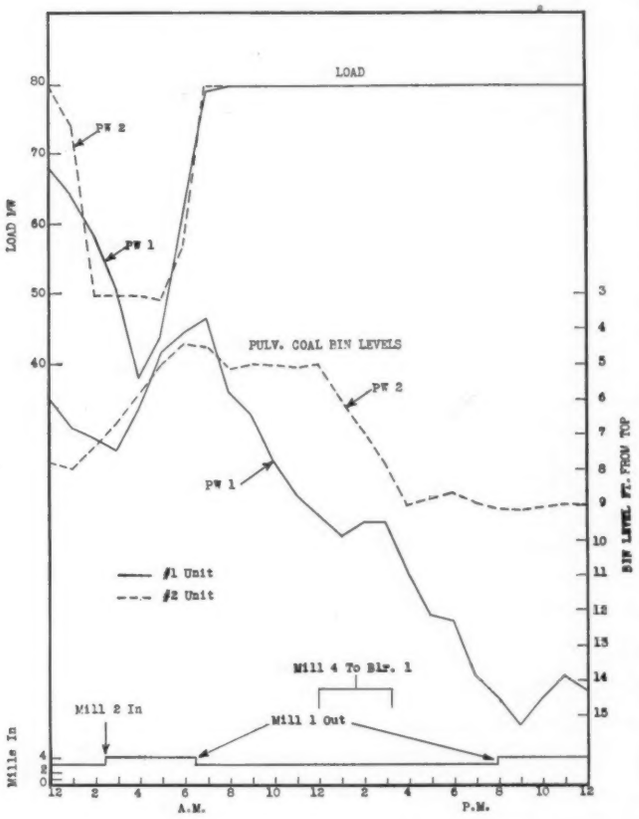


Fig. 3—Value of pulverized coal storage

Though all mills are inadequate to carry full load continuously, by about 10 per cent, the above shows full load carried for 17 hr with one of the four mills being overhauled.

was out $13\frac{1}{2}$ hr for overhaul. This dependence upon pulverized coal storage has been found thoroughly practical, and with improvements in "bin and feeder" firing has made the storage system most desirable for Port Washington conditions.

Port Washington No. 3

A third unit, now under construction, employs essentially the same principles of design as the two earlier units. The boiler is about three-quarters erected, and the turbine-generator continues to be delayed by a prolonged strike of the manufacturer's production employes.

The photograph on the cover of this issue shows the tube-rolling operation at the lower drum of this boiler. Tube-rolling control records are kept for each tube, and axial tube extrusion is measured by a dial micrometer.

Reduce Fuel Bills

You can reduce fuel bills; make it easier to keep up steam, and reduce the temperature of the engine room by covering valves, flanges and bare fittings with R & I Stic-tite Insulating Cement.

Stic-tite saves 90% of the fuel loss of bare surfaces. Covers twice as much area as ordinary insulating cement, and has double the insulating value.

It sticks like glue, is easy to apply and lasts for years. Trowels to a smooth, hard finish.

Get it from your supply house.

Write us for Bulletin 1-75.

REFRACTORY & INSULATION CORPORATION

124 Wall Street, New York 5, N. Y.

Chicago 4, Ill. — Philadelphia 3, Pa.

Detroit 16, Mich. — Newark 2, N. J.

R&I Stic-tite Insulating Cement

Feed Distribution and Hunting in Marine Boilers

The following are excerpts from a comprehensive and lengthy paper by H. Hillier which was presented before the Institution of Mechanical Engineers in London on November 8. In it the author reviewed experiences with hunting of the water level in three-drum naval boilers at certain loads, gave an analysis of the phenomenon and described its elimination by arrangement of the internal feed-distributing pipe so as to spray the water into the steam space.

IN CONSIDERING the phenomenon of hunting, it is important to distinguish between irregular changes in the boiler water level and the rhythmical and continuous variation in the water level which occurs with a definite period cycle. Normal changes in the rate of steam draw-off and the rate of fuel combustion cause irregular changes in the boiler water level. Dirt or foreign material or any other cause that results in stickiness of the feed regulator also produces irregular changes in water level. Such changes are irregular in incidence and amplitude. However, when hunting occurs, the changes are quite regular, with a definite time cycle and with an amplitude that is repeated continuously.

The first two arrangements of internal feed piping fitted in boilers of the three-drum type in British naval vessels during the period 1919–1939 are shown in Figs. 1-a and 1-b. That shown in Fig. 1-a was fitted in a large number of boilers and consisted of a single $4^1/_2$-in. internal feed pipe arranged down the middle of the steam drum and immediately over the fire row of tubes. The pipe was perforated with holes which were evenly pitched along the length of the pipe. No hunting was experienced with these ships.

The second arrangement, shown in Fig. 1-b consisted of two internal feed pipes with the perforations arranged to discharge the entering feedwater toward the outer tubes so that relatively cold entering feedwater passed into these tubes which were operating as downcomers. The object of this design was to increase the circulation in the boiler and so permit higher ratings.

With this second arrangement very slight hunting, of the order of 3 in. in water level at about one-quarter load, was experienced with some cruisers. At higher loads the water levels were steady. In one cruiser, however, serious hunting was encountered, the swing in water level in the gage glass being some 8 in. with a periodicity of 3 to 4 min. The greater severity of this hunting was attributed to the feed pumps being larger than those in the other cruisers.

Circulation Augmenter

Development in the design of boilers to operate at higher ratings finally led to introduction of the circulation augmenter which isolated the discharge of steam and water from the upstream tubes from the remainder of water in the drum. Boilers first fitted with augmenters were provided with twin internal feed-distributing pipes as shown in Fig. 1-c. This arrangement was employed in the boilers of some destroyers, cruisers and an aircraft carrier. It resulted in even more serious hunting, usually at about one-third load, but in some cases at all powers with a periodicity of 3 to 4 min. The hunting took place only when two or more boilers were steaming in parallel, steady operation being obtained when each boiler was operated alone. The hunting fluctuations at all loads

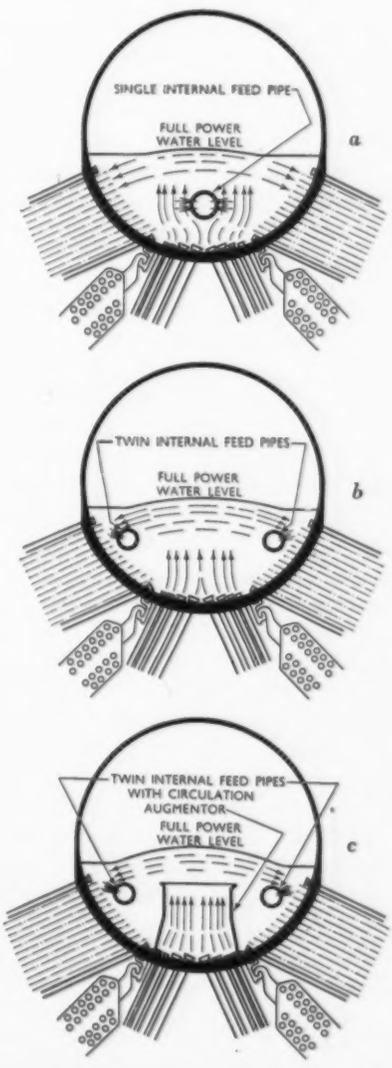


Fig. 1—Successive arrangements of internal feed piping

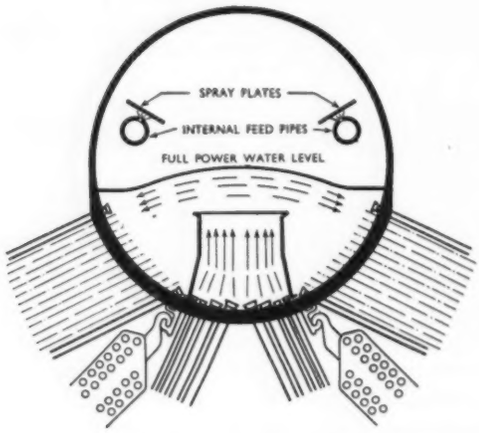


Fig. 2—Internal feed pipes spraying into steam spaces

were eliminated when the internal feed pipes were raised so as to spray the incoming feedwater into the steam space, as shown in Fig. 2.

This, however, was attended by another trouble. When maneuvering, the water level varied appreciably due to swelling and subsidence, which caused the feed regulator to open and close more sharply than in normal steaming; with the consequence that water-hammer was experienced in the internal feed pipes when the feed regulator opened after a previous closure. This was attributable to the pipes being partially emptied of water following closure of the regulator, due to momentum of the column of water in the piping. The pipe was then partially filled with steam and, on the reopening of the regulator, the relatively cold feedwater condensed the steam in the piping, thereby giving rise to considerable acceleration of the column of water.

To eliminate this trouble, the arrangement shown in Fig. 3 was developed and gave entirely satisfactory results. Hence, practically all Admiralty type boilers for the naval ships completed during the war were fitted with this arrangement. In this two internal feed pipes are led below the water level in the drum and-vertical spray pots are connected to these pipes at intervals to obtain a reasonable distribution of water along the length of the drum. At a suitable height in each spray pot, perforations are provided through which the feedwater is sprayed to the wing of the drum and each pot has a hood to deflect the water downward. This minimizes the possibility of water being carried into the outlet with the steam. Also, the vertical spray pots are open at their upper ends to avoid any possibility of water-hammer.

The spraying of the water through the perforations is effected by the static head above them, the limit in the available head being the height of the open end of the pot. When the feed regulator closes, the water level in each spray pot falls to the level of the lowest row of holes, so that the longitudinal feed pipes are maintained full of water and any steam ingress which might give rise to water-hammer is avoided.

At the time these spraying pots were adopted, another feature relating to feed control was put into effect in boilers fitted with augmenters. In fact, all British naval boilers constructed during the 1939–1945 war period to operate at high evaporation rates, were fitted with circulation augmenters. These, (1) isolate the light mixture of steam and water discharged from the upstream tubes from the remainder of the water in the drum, thereby reducing the density of the water column against which the upstream tubes discharge; and (2) they increase the density of the column of water in the downcomer tubes, thereby increasing the thermo-syphonic head which produces circulation.

Fig. 4 shows diagrammatically the arrangement of the augmenter and indicates the levels which prevail inside the drum. The no-load water level is determined by the position of the float in the float box and the full-load water level in the gage glasses by the height of the upper end of the water balance pipe inside the augmenter. Water in the float box and gage glass is higher in density than that inside the augmenter because the water in the float box and gage glass is free from steam.

Above the top of the water-balance pipe is a steam-water mixture of much lighter density, and this density

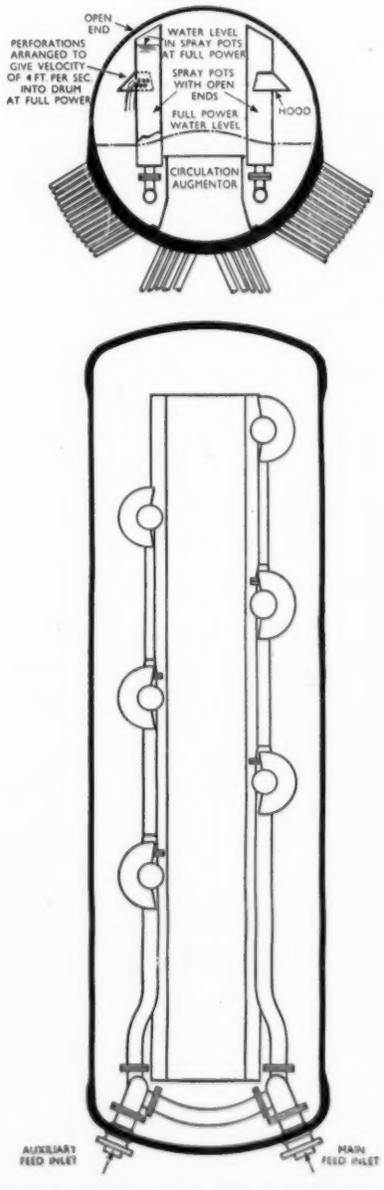

OPEN END
PERFORATIONS ARRANGED TO GIVE VELOCITY OF 4 FT PER SEC INTO DRUM AT FULL POWER
WATER LEVEL IN SPRAY POTS AT FULL POWER
SPRAY POTS WITH OPEN ENDS
HOOD
FULL POWER WATER LEVEL
CIRCULATION AUGMENTOR
AUXILIARY FEED INLET
MAIN FEED INLET

Fig. 3—Spray pots arranged to spray feed into steam space

decreases approximately in proportion to the boiler load. Referring to the sketch, this light column A' above the end of the pipe balances the denser column of water A in the float box. The water column C' in the gage glass is balanced by a lighter column C in the boiler drum outside the augmenter. The column of water B' outside the augmenter plate is balanced by the column of steam-water mixture B inside the augmenter. There is also the

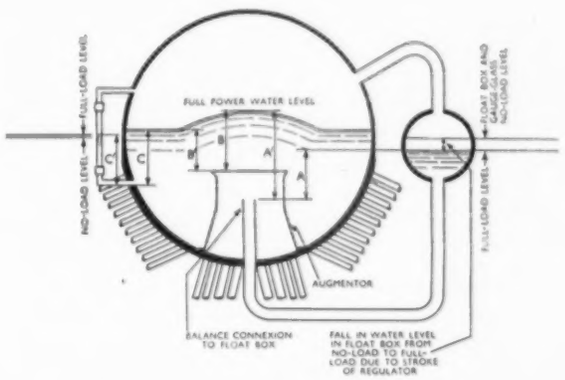

FULL POWER WATER LEVEL
NO-LOAD LEVEL
FULL-LOAD LEVEL
FLOAT BOX AND GAGE-GLASS NO-LOAD LEVEL
FULL-LOAD LEVEL
AUGMENTOR
BALANCE CONNEXION TO FLOAT BOX
FALL IN WATER LEVEL IN FLOAT BOX FROM NO-LOAD TO FULL-LOAD DUE TO STROKE OF REGULATOR

Fig. 4—Balance connection to float box taken from inside the augmenter

weir effect across the top of the augmenter which varies with the rate of evaporation. By varying the height of the water balance pipe, for the fall in water level in the regulator float box corresponding to the fall of the float between no flow and the feed flow for maximum evaporation, the water level in the gage glass can be caused to fall any desired degree, to remain substantially constant, or to rise slightly.

Of course, the arrangement shown in Fig. 4 has no connection with the hunting previously mentioned.

Short Cut in Vapor Calculations

By A. H. ZERBAN

State College, Pa.

MOST textbooks give the usual method of calculating the enthalpy of wet saturated steam as

$$h_x = h_f + xh_{fg} = h_f(1 - x) + xh_g$$

where x is the quality or dryness, expressed as a decimal, and the remaining nomenclature is in accordance with the steam tables; that is, h_f and h_g are, respectively, enthalpy of the liquid and enthalpy of the saturated vapor; and $h_{fg} = h_g - h_f$ is the enthalpy of vaporization. For high values of quality, however, relatively poor accuracy results with respect to significant figures when worked on a slide rule, and long-hand calculations are somewhat laborious. Convenient and accurate calculations, on the other hand, can be made by using the expression

$$h_x = h_g - (1 - x)h_{fg} = h_g - yh_{fg}$$

where $y = 1 - x$ = moisture, expressed as a decimal. Similar expressions can be evolved for entropy, specific volume and internal energy.

To illustrate the convenience and accuracy of this method, let it be required to find the enthalpy of steam at 100 psi abs pressure and 98 per cent quality. Instead of writing

$$h_x = 298.40 + (0.98)(888.8)$$

we write

$$h_x = 1187.2 - (0.02)(888.8) = 1187.2 - 17.776 = 1169.4$$

The above is easily worked without use of a slide rule but even where a slide rule is used, this method yields greater accuracy than the conventional method. For example, to determine the properties of steam at standard atmospheric pressure after expansion at constant entropy s_x from an initial condition of 600 psi abs and 800 F, take the entropy, 1.6343, and solve for the moisture at 14.7 psi abs (s_g = entropy of saturated vapor, s_{fg} the increase in entropy during vaporization at the lower pressure and y the percentage of moisture).

$$s_x = s_g - ys_{fg}$$

$$1.6343 = 1.7566 - (y)(1.4446)$$

so that

$$y = \frac{1.7566 - 1.6343}{1.4446} = \frac{0.1223}{1.4446} = 0.0846$$

and the quality is thus found to be 91.54 per cent. The enthalpy is then

$$h_x = 1150.4 - (0.0846)(970.3) = 1150.4 - 82.1 = 1068.3$$

Or, to take the familiar example of the throttling calorimeter, let it be required to determine the quality of steam at 200 psi abs when the throttling calorimeter reads 260 F at 16 psi abs, and the enthalpy is found in the superheat tables to be 1173.4 Btu per lb. Then,

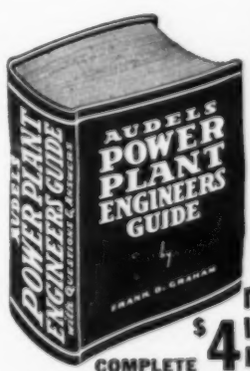
$$1173.4 = 1198.4 - (y)(843.0)$$

so that

$$y = \frac{1198.4 - 1173.4}{843.0} = \frac{25.0}{843.0} = 0.0296$$

and the quality is 97.04 per cent.

Obviously, similar use of this method can be applied to the determination of the properties of other wet vapors such as refrigerants.



ENGINEERS INFORMATION

QUESTIONS and ANSWERS

JUST OUT! Audels Power Plant Engineers Guide. A complete Steam Engineers Library covering Theory, Construction & Operation of Power House Machinery including Steam Boilers, Engines, Turbines, Auxiliary Equipment, etc. 65 chapters, 1500 Pages, over 1700 Illustrations, 1001 Facts, Figures and Calculations for all Engineers, Firemen, Water Tenders, Oilers, Operators, Repairmen and Applicants for Engineer's License.

FREE TRIAL!

AUDEL, Publishers, 49 W. 23 St., New York 10

MAIL AUDELS POWER PLANT ENGINEERS GUIDE for free examination. If O.K. I will send you $1 in 7 days; then remit $1 monthly until price of $4 is paid. Otherwise I will return it.

Name_____

Address_____

Occupation_____

Employed by_____

COMPLETE $4

PAY ONLY $1 A MO.

Get this information for Yourself. Mail Coupon Today. No Obligation Unless Satisfied. ASK TO SEE IT.

Standardized Turbine-Generator Units

By J. R. Carlson

Westinghouse Electric Corp.

A LITTLE over a year ago, a joint committee of the A.I.E.E. and the A.S.M.E. submitted a report suggesting certain preferred turbine-generator standards. These do not preclude users from purchasing non-standard equipment. However, in the range of sizes from 10,000 to 60,000 kw, many economies can be realized in the purchase and use of the standardized machines.

One of the problems faced in the standardization program was the many existing heat-balance arrangements. It soon became obvious that it would be possible to group extraction pressures into narrow ranges. Data available showed that extraction pressures could be varied widely with practically no change in efficiency. The problem before the committee then was one of resolving extraction pressures into economic practical values which would produce results acceptable to the majority. In accomplishing this (see Table 1), the ideas of dozens of users as well as those of the manufacturers were weighed and carefully analyzed. The temperature of the feedwater to the boiler had an effect on its design and was considered so as to result in not only an efficient heat-balance arrangement, but also an economic boiler and turbine.

TABLE 1—EXTRACTION PRESSURES AT TURBINE CASING AT FULL LOAD WHEN OPERATING WITH STAGE HEATING

Heater No.	Abs Pressure, Psi	Saturation Temp, F
1	6.72	175
2	22.8	235
3	53.2	285
4	134.6	350
5*	276.7	410

* Fifth extraction point is not available in ratings of 11,500, 15,000 and 20,000 kw.

These pressures are those that exist at rated load when operating feed heating. However, it is not enough to specify what the extraction pressures should be as they vary with the steam flow. A change in the vacuum or a change in the number of heaters used will change the steam flow through the turbine for a given output. For example, the rated load steam flow applying to a 30,000-kw turbine with steam applied at 850 psig, 900 F and an absolute exhaust pressure of 1 in. and 2 in. of mercury with two, three, four and five stages of feedwater heating is as shown in Table 2.

If the stage pressures are proportioned for four stages of extraction at 1 in. of mercury absolute, the pressures will be about 5 per cent higher when operated at 2 in. absolute and five stages of feedwater heating. It should also be noted that the steam flow through the high-pressure nozzles varies with the number of heaters used.

The Committee recommended that the design exhaust pressure for the turbine be 1.5 in. Hg abs. Such a design condition would result in a turbine of sufficient exhaust annulus to produce a good overall efficiency through the usual range of vacua. It was also specified that the nominal capability output of the turbine would also be obtained at 1.5 in. Hg abs. With such a limitation, turbine users in the South and Middle West were penalized as their maximum load occurs during the hot summer months when the vacuum is the poorest.

This difficulty was circumvented by nozzling the turbine so it would develop 110 per cent of rating with five stages of feedwater heating and with $2^1/_2$ in. absolute back pressure. Expressed in another manner, the exhaust end was proportioned to give good efficiency with absolute back pressure of 1.5 in., but by increasing the nozzle capacity a small amount the standard turbine would develop its guaranteed capability even with poor vacuum conditions. This small increase in size of the high-pressure nozzles made the standardized turbines highly acceptable. Those users who operate with a reduced number of heaters or with higher vacua merely obtained increased turbine capacity and, incidentally, unit output which has the full approval of the manufacturer.

The effects of variations in exhaust pressure on turbine capacity for the six standardized sizes are shown in Table 3.

The reduction of turbine capacity with reduced operating pressure of 50 lb is shown in Table 4.

TABLE 4—VARIATION IN TURBINE CAPABILITY WITH A 50 LB REDUCTION IN THE THROTTLE PRESSURE

Initial Steam Pressure, psig	Initial Steam Temperature, F	Per Cent Reduction in Kw Capability
600	825	9
850	900	6
1250	925	4

For a 50-deg reduction in operating temperature, the kilowatt capability of the turbine will be reduced by 2 per cent. When operated with designed conditions, the turbine capability will be increased by

TABLE 2—VARIATION IN TURBINE THROTTLE FLOW WITH VARYING NUMBER OF STAGES OF FEEDWATER HEATING AND VARIABLE VACUUM

Stages of Feedwater Heating	Pounds of Steam per Hour — 1.0 In. Hg — Steam to Turbine	1.0 In. Hg — Steam to Condenser	2.0 In. Hg — Steam to Turbine	2.0 In. Hg — Steam to Condenser
2	254,500	197,700	263,400	205,000
3	255,900	194,700	265,500	202,000
4	257,700	192,000	267,700	199,400
5	259,700	190,100	269,900	197,600

TABLE 3—CHANGE IN MAXIMUM TURBINE CAPABILITY WITH VARIATIONS IN EXHAUST PRESSURES

Initial Steam Pressure, psig	Initial Steam Temperature, F	Per Cent Change in Kw Capability Exhaust Pressure — In. Hg Abs — 1.0	1.5	2.0	2.5	3.0	3.5
600	825	+3.9	+3.1	+1.8	0	−1.9	−4.0
850	900	+3.3	+2.6	+1.4	0	−1.7	−3.5
1250	950	+2.6	+2.0	+1.2	0	−1.5	−3.0

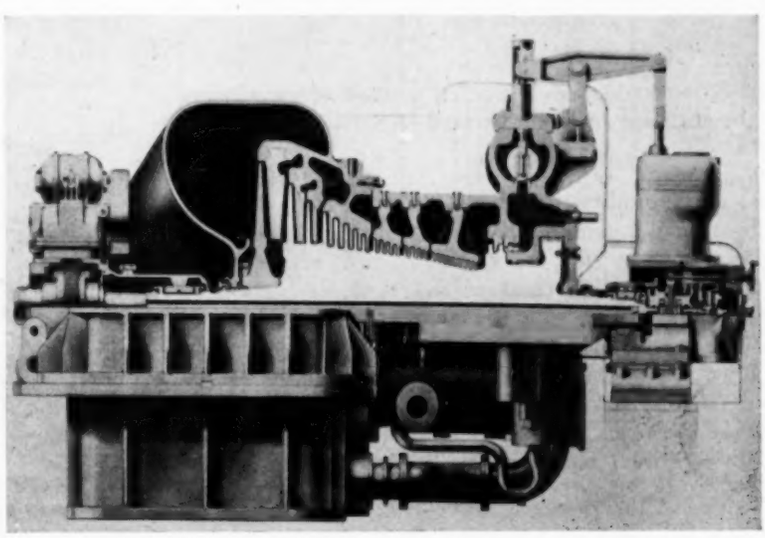


Fig. 1—Longitudinal section of 25,000-kw condensing turbine

TABLE 5—PREFERRED STANDARD FOR LARGE 3600-RPM 3-PHASE 60-CYCLE CONDENSING STEAM TURBINE-GENERATORS

1.	Turbine-generator rating, kw	11,500	15,000	20,000	30,000	40,000		60,000
2.	Turbine capability, kw	12,650	16,500	22,000	33,000	44,000		66,000
3.	Generator rating, kva	13,529	17,647	23,529	35,294	47,058		70,588
	Power factor	0.85	0.85	0.85	0.85	0.85		0.85
	Short-circuit ratio	0.8	0.8	0.8	0.8	0.8		0.8
4.	Throttle pressure, psig	600	600	850	850	850	1250	850 1250
5.	Throttle temperature, F	825	825	900	900	900 or	950	900 or 950
6.	Number of extraction openings	4	4	4	5	5		5
7.	Sat. Temp. at 1st extr. opening	175	175	175	175	175		175
8.	Sat. Temp. at 2nd extr. opening	235	235	235	235	235		235
9.	Sat. Temp. at 3rd extr. opening	285	285	285	285	285		285
10.	Sat. Temp. at 4th extr. opening	350	350	350	350	350		350
11.	Sat. Temp. at 5th extr. opening	...	...	...	410	410		410
12.	Exhaust pressure, in. Hg abs	1.5	1.5	1.5	1.5	1.5		1.5
				Hydrogen-Cooled Generator Operated at 15 Psig Hydrogen Pressure				
13.	Generator capability at 0.85 power factor, kva			27,058	40,588	54,117		81,176

NOTES:

(1) A tolerance of plus or minus 10 F shall apply to the above saturation temperatures. (Tolerances shall be unilateral so as not to reduce the spread in temperature between adjacent extraction openings.)

(2) "Turbine capability" is guaranteed continuous output at generator terminals when the turbine is clean and operating under specified throttle steam pressure and temperature and exhaust pressure, with full extraction from all extraction openings.

14.	Standard generator voltages (all sizes)			11,500	12,500	13,800	14,400

4 per cent when no steam is extracted from the highest extraction outlet.

The standardized turbine-generator unit as a whole is more closely matched between turbine and generator. "Conventional turbines" are nozzled to develop 125 per cent of rated load or the kva capacity of the generator at unity power factor. The only way the full turbine capacity can be utilized with an air-cooled generator is to raise the power factor to unity. With a hydrogen-cooled generator, the situation is not so unbalanced as 15 per cent greater generator capacity can be obtained with 15 lb gas pressure over $^1/_2$ lb normal gas pressure. This will permit developing the maximum turbine capability with a power factor of 87 per cent.

In the past, generators were normally designed for a power factor rating of 80 per cent. Today it is evident that the average operating power factor is nearer 90 per cent. A saving in generator costs can be obtained by designing it for a power factor of 85 per cent instead of 80 per cent. Standardized turbines have a maximum capacity of 10 per cent in excess of rating. When matched with the new 85-per cent power factor generators, air-cooled or hydrogen-cooled at $^1/_2$ lb gas pressure, their maximum capability can be obtained with a power factor of 93.5 per cent instead of 100 per cent with the conventional machines. At 15 lb gas pressure, on hydrogen-cooled generators the power factor need only be 83 per cent as compared with 87 per cent. (All generators are hydrogen-cooled except the two smallest ratings.)

A number of years ago very little thought was given to generator short-circuit ratio. As system capacities increased, a general feeling developed that short-circuit ratios should be high to permit stable operation. The work of the standardization committee showed that generator short-circuit ratios in Europe and this country varied from 0.6 to 1.2. Their investigation also showed that unless there were extenuating circumstances, short-circuit ratios of 0.8 were entirely ample, thus again resulting in a saving in the amount of iron and copper built into the generator.

All hydrogen-cooled generators have a heavy steel gas-tight housing or shell enclosing the generator proper. Enclosed in this housing are the hydrogen gas coolers. These gas coolers can be designed for any cooling-water temperature from 70 to 95 F. The size of the 95-deg gas cooler is several times as large as that for the lower temperatures. To reduce the number of gas-tight housings for conventional generators, the manufacturers developed two; one which would accommodate gas coolers for water temperatures through 85 F, and a second one large enough to accommodate gas coolers designed for 95 F. The Committee concluded that the need for 95 F cooling water was rather remote and one housing capable of accommodating gas coolers designed for 90 F cooling water was sufficient.

Standardization has very definite advantages to the user, and these are as follows:

1. Lower costs which should result in cheaper power plants. For example, a standardized 30,000-kw turbine-generator

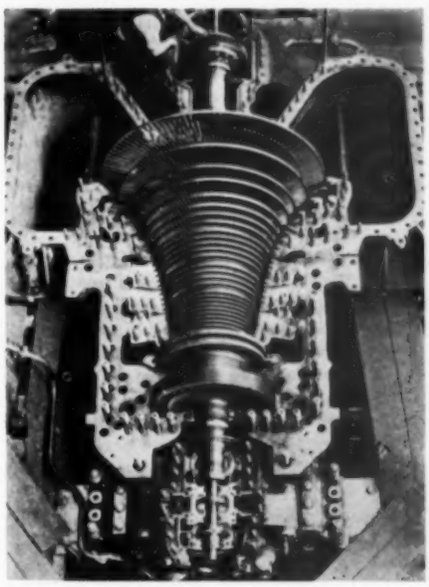


Fig. 2—Typical construction of standardized turbines in sizes of 11,500, 15,000, 20,000 and 30,000-kw.

... Controls All!

With Beaumont Birch Coal Handling Equipment, one operator controls *all* coal handling with finger-tip controls, like this—

Coal arrives by rail, is dumped into hopper, raised by bucket elevator and discharged either into bunker for immediate use or down a chute to yard storage. If it goes to storage, the Beaumont Drag Scraper spreads it into safe, compact layers—eliminating air pockets.

Use any available space. Tail-blocks can be slung between posts and moved by hand—and mechanically moved on I-beam track, by tail-block car, or suspended from an aerial bridle system. The scraper and cable system is operated by *one* man through remote control. *One* company, Beaumont Birch, supplies all necessary equipment.

Complete engineering service available by writing right now to—

BEAUMONT BIRCH COMPANY
1506 RACE STREET • PHILADELPHIA, PA.

Designers Manufacturers Erectors BULK MATERIAL HANDLING SYSTEM

Do S. E. Co. Coal Scales Use an Endless Belt?

Cut a slip of paper, measuring about 2" x 8", to represent an endless belt—then try to break it by pulling on it in opposing directions (as in the first sketch at the right). A good lateral pull won't tear it. Now, cut the slip of paper into two 4" x 2" sections and staple or pin the pieces together, end to end, to simulate a fastened belt. A very slight pull will separate the pieces at the point where they are fastened, as in the lower sketch.

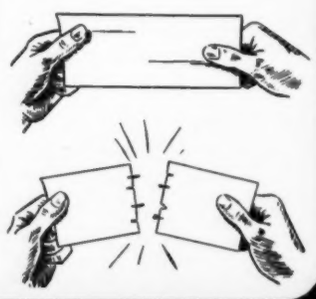
The added dependability and strength of the endless belt is obvious . . . and that is just one of the many "extras" you get with S. E. Co. Coal Scales.

Want more information? Write to the

STOCK ENGINEERING COMPANY
713 Hanna Bldg.,
Cleveland 15, Ohio

Yes!

...make this test to demonstrate its efficiency to yourself!



STOCK ENGINEERING CO.

★
CONICAL
Non-Segregating
Coal Distributors
★
S.E.CO.
Coal Valves and Coal Scales

unit costs approximately the same as the conventional 25,000-kw machine.

2. Quicker shipment. The engineering work will all be completed on the standardized units and the work can be entered in the shop with a minimum of delay. In fact, if the activity is great enough, parts or complete turbines can be stocked.

3. Greater reliability. Receptive manufacture permits the manufacturing difficulties to be eliminated. Continued operation of duplicate units would soon disclose any inherent design weakness, which can be readily corrected and avoided in later machines.

4. Standardization of extraction openings. The location of extraction zones in the turbine are in accordance with the best engineering knowledge of the country. Heat balances worked up from these standards should almost automatically be free of trouble.

5. Turbine and generator are coordinated. The maximum turbine capability and generator kva capacity are coordinated so as to permit the maximum utilization of both in the production of kilowatt output.

6. Steam pressures and temperatures which no longer should be considered independent variables are carefully matched. For each pressure, an operating temperature is selected which results in good low-pressure blade life. Furthermore, except for the two largest ratings, 40,000 and 60,000 kw, only one definite but economic operating steam condition is used for each rating. For the two largest ratings, a choice of two economic operating conditions is provided.

American Firm Receives French Order for Controls

Bailey Meter Company has received a large order for steam plant controls from the Union d'Electricite of Paris, France for its Gennevilliers Power Plant. This order provides for complete metering equipment and coordinated controls for combustion, feedwater and superheated steam temperature to be installed on six 530,000-lb per hr steam boilers operating at 1325 psig and 980 F.

This steam plant will be on a distribution network with hydraulic plants and will, on occasion, be required to pick up full load instantaneously.

The combustion control consists of standard Bailey air-operated units of the metering type and includes a master steam-pressure controller for all boilers and a fuel-air ratio controller for each boiler. The boilers can be operated on base load at a constant rating or may be regulated automatically in accordance with variations in steam pressure. The fuel flow-air flow ratio and furnace pressure controls are automatic at all times. The boiler feedwater, supplied by motor-driven feed pumps, will be controlled by air-operated three-element feedwater control, and steam temperature will be maintained constant at any desired value between 750–980 F by an air-operated three-element system.

Annual Water Conference Held in Pittsburgh

THE major portion of the three-day program of the Seventh Annual Water Conference at Pittsburgh on January 6–8 was devoted to feedwater and boiler water problems.

German Practice

At the first session **W. W. Cerna,** of Hall Laboratories, told of German water conditioning practice as he observed it during an immediate post-war visit as a member of a U. S. Government field team. High-pressure boilers operating between 1200 and 1800 psi with steam at 900 to 950 F were common, even among industrial plants, and the methods of water conditioning, with a few exceptions, were basically the same as those employed in the United States.

Of particular interest were the "Wofatit" group of synthetic resins having exchange properties, some of which were used for final softening at temperatures as high as 210 to 212 F, following hot-process precipitation type softeners.

Silica reduction systems for treatment of boiler makeup were commonly employed and in cold-process systems, silica reduction was obtained through the use of equi-molecular quantities of sodium aluminate and magnesium chlorides. In hot-process systems, dolomitic lime, lime and magnesium oxide, or caustic soda and magnesium oxide were used to produce a combination of carbonate hardness and silica reduction.

Also ammonia and ammonium chemicals, such as ammonium phosphate and ammonium sulphate were used extensively for feedwater, boiler water and condensate conditioning, it being claimed that in the absence of oxygen, ammonia concentrations up to a maximum of 10 ppm as NH_3 would not attack nonferrous metals such as used for condenser tubes. Use of ammonia in the treating system was said to provide a neutralizing agent for acids, such as carbonic acid frequently occurring in steam condensate; and, with slight excess NH_3, produced alkaline water of the desired pH value.

Determination of Dissolved Oxygen

Dr. R. C. Ulmer, of E. F. Drew & Co., reviewed briefly the various aspects of the determination of the endpoint in the tests for dissolved oxygen in water. He pointed out that the starch method is unsatisfactory because of lack of sensitivity and errors involved, whereas certain methods, especially the one based on potentiometric titration, are also unsatisfactory because they are more or less complicated.

The paper presented a method based on the null or dead-stop endpoint in which a commercially available apparatus employing the magic-eye radio-tuning tube is employed. Such apparatus is used by several large utilities for routine checking of dissolved oxygen.

Improvement of Steam Quality

The improvement of steam quality was discussed in a paper by **A. L. Jacoby** and **W. H. Thompson,** of National Aluminate Corporation, from the standpoint of total quantity of solids in the steam. Wet steam, they pointed out, is due to carryover which may be caused by slugs, splashing or foaming. Dealing only briefly with the first two causes, the authors discussed at some length the causes and prevention of foaming. Foam may be stabilized by soluble, colloidal and insoluble materials, the mechanism of each being dealt with. There are also recently developed antifoam materials comprising certain polyamides.

Identification of Types of Carryover

P. B. Place, of Combustion Engineering Company, stated that there are four common types of carryover, namely, priming, foamover, spray and leakage; and that it is desirable to identify the type involved in order to facilitate correction of the trouble.

These types are affected to different degrees by changes in the mechanical, water and operating conditions, and the type may be identified by determining the effects of these various changes.

There are two distinct phases of a carryover development. First, there is the development of sources of carryover within the boiler, and second, there is development of actual carryover from the boiler. If high water levels, atomization of boiler water and formation of foam films did not develop in a boiler there would be no priming, spray carryover or foamover. On the other hand, all three may be present without causing actual carryover. Carryover problems occur when these sources exceed the limit of the drum internals to control them.

In making tests for identification of types of carryover and the sources, continuous readings on such major factors as rating, boiler-water concentration, water level and steam purity, should be taken over a period in which a number of operating conditions are varied.

Priming is easily identified and is usually due to too high water level, spouting of submerged riser tubes, to sudden swelling of the water in the boiler, to drop in pressure, or to sudden increase in rating.

Leakage carryover may be troublesome because it is often localized. Local sampling lines may be necessary to confirm a leakage condition; but where leakage is sufficient to register in purity tests of the total steam flow, it will be found that the impurity increases slowly and steadily with rating and is relatively insensitive to changes in water level and in boiler-water concentration.

Spray carryover covers a wide range from small amounts of atomized mist to heavy carryover when the capacity limits of the boiler or drum internals are much exceeded. Thus spray carryover is not sensitive to changes in boiler-water concentration, but will change to foamover when foaming develops in the boiler. This type of carryover is characterized by initial development at less than full rating and by a constant increase with increase in rating.

Foamover is the most common, the most troublesome and the most erratic type of carryover. Any carryover condition that can be precipitated or eliminated by a change in boiler-water concentrations, other operating conditions being equal, may safely be assumed to be due to foaming. When operating just below a critical concentration limit, this type of carryover is very sensitive to minor operating conditions such as a change in rating, feeding chemicals, or to minor changes in water level. However, such sensitivity may lead to false conclusions as to the source of the trouble. Under foaming conditions, a blanket of foam usually accumulates on the water level, and by means of special test lines this foam blanket can be confirmed. It may be from ten to twenty inches deep.

Silica Deposits in Steam Turbines

F. R. Owens of Cyrus Wm. Rice Company, presented plant and laboratory data showing that silica concentration in a water may increase by softening through natural zeolite. This increase is a function of temperature, growth of organic matter, number of regeneration cycles, hydrogen ion and total ion concentration of the water.

Silica deposits have been encountered at and below 600 psi that would not respond to washing for removal, and the author presented data comparing the effectiveness of washing and fly-ash blasting for the removal of deposits consisting almost entirely of silica.

Evidence of a change in molecular structure of silica as a result of superheating saturated steam is shown through colorimetric determinations. Mr. Owens subscribed to the theory of selective vaporization of silica, but suggested that the form of the silica is $SiO_2 \times H_2O$.

Removal of Silica Deposits

A method for removal of silica from turbine blades was described by **D. Forty** of the Public Service Corporation of Northern Illinois.

One of the major problems confronting operators of steam generating stations employing pressures over 800 psi has been the loss of turbine capacity and efficiency as the result of silica being carried over with the steam and deposited on the turbine blading. Deposits in the lower stages have been hard and insoluble in water, so that washing could not be employed. On the other hand, dismantling and cleaning by blasting with an abrasive is expensive and means taking the turbine out of service.

Therefore, where conditions are such that silica in the boiler water cannot be controlled, it is advisable to resort to chemical cleaning. Such a means was tried at the Joliet Power Station where the installation of a 1250-psi topping turbine

NEW SAFETY IN GASKETS

"Flexitallic" GASKETS
How Flexitallic Precision Brings a New Degree of Safety
for sealing steam and other fluids under pressure
FLEXITALLIC
8th & Bailey Sts.

WILL YOU READ ABOUT IT?

This new little book speaks of safe-sealing for fluids under pressure with the plain honesty the subject of safety deserves.

It tells with sketches and few words how the "Flexitallic" art which established itself in wide use through safe performance has now put safety on a new level.

You are not asked to abandon one theory and accept another. The book deals with a record of performance and identifies the practices that make the record possible. You are urged to believe only what pre-testing can—and will—prove to you.

We'll send you a copy

A post-card will serve but you will help us in record-keeping by giving us the name of your company and your title or department.

Originators of Spiral-Wound Gasket Construction

"Flexitallic"

Gaskets of this name are manufactured only by

FLEXITALLIC GASKET COMPANY
8th and Bailey Streets Camden, N. J.

resulted in deposits being formed on the blading of two 10,000-kw and one 30,000-kw turbine operating at 300 psi from the exhaust of the high-pressure turbine.

Experiments were made using a sodium hydroxide solution injected into the steam at low turbine speed and a steam temperature slightly above saturation. The method proved effective.

A symposium followed on "Silica Removal by Ion Exchange" to which four papers contributed. One by **W. W. Jukkola** and **R. B. Thompson** of the Dorr Company dealt with methods of applying the fluoride process to the removal of silica in conventional de-ionization equipment as well as in auxiliary exchange cells. Also, a cyclic process was outlined whereby fluorides are recovered and used again.

The second paper, by **M. E. Gilwood**, of Permutit Company, discussed different methods of removing silica and stated that silica may be removed from waters containing low dissolved solids cheaply if demineralizing treatment is not desired. Demineralized silica-free water is now available by commercial processes. The author emphasized the desirability of first making an engineering economic study in each case before deciding upon the treatment to be employed.

W. C. Bauman, of Dow Chemical Company, stated that complete removal of silica from water had been attained with ion exchange resins. Silica is converted to fluosilicic acid and removed as such by anion resin. Three methods of fluoride addition for silica removal and six different anion resins have been used. Alkali regeneration of exhausted anion beds must be preceded by acid or salt treatment to avoid precipitation of silica in the anion exchangers. The author explained that this method of silica removal is best suited for silica concentrations below 10 ppm.

W. S. Morrison, of Illinois Water Treatment Company, discussed the work of Professor Straub and Walter Leaf on the use of various chemicals for silica removal and described a method that is now being put into service to remove silica in a water from 8.5 ppm down to an effluent concentration of not more than 0.2 ppm, by using an anion and cation unit placed in series at a flow rate of 500 gpm.

Other papers at the Conference discussed the effects of gases in water, iron and manganese removal, the clarification of industrial wastes, trends in the re-use of water, applications of ion exchange, and base exchange in waste water treatment.

Purchases Line of Steam-Jet Ash Conveyors

Beaumont Birch Company, Philadelphia, has purchased the complete line of Hagan Steam Jet Ash Conveyors from the George J. Hagan Company of Pittsburgh, Pa. Hereafter, replacement parts for these conveyors will be furnished by Beaumont Birch and, in addition, important features of the Beaumont "Vac-Veyor and "semi-Vac-Veyor" systems will be available to further improve the efficiency and economy of the Hagan Line. The George J. Hagan Company will continue the manufacture of other lines of industrial equipment.

Central Station Turbine Orders

In reviewing the year just past, Westinghouse Electric Corporation states that in the twelve months following V-J Day, it received orders for 45 central-station type turbine-generators totaling 1,600,000 kw. Of these ten were in the 10,000- to 15,000-kw range; nineteen were 20,000 to 35,000 kw; eleven 40,000 to 50,000 kw; one 67,000 kw; two 75,000 kw; one 80,000 kw and one 105,000 kw. Only the two 75,000-kw units are for operation at 1800 rpm, the others being for 3600 rpm. The 105,000-kw unit for the new Sewaren Station in New Jersey will operate with steam at 1500 psig and 1050 F.

A review statement by the General Electric Company says:

"Among the many turbine-generator sets under construction during the year there were three large ones which will indicate the trend toward higher pressure and temperature conditions, and hence toward higher operating efficiency. Particularly outstanding was the 125,000-kw equipment for the Pomeroy Station of the American Gas and Electric Company which is expected to consume considerably less than 10,000 Btu per kwhr. Steam conditions will be 2000 psi and 1050 F temperature.

"Two 100,000-kw turbine-generator sets are being built for the Public Service Electric and Gas Company of New Jersey. One will operate at 1500 psi, 1050 F and the other at 1250 psi, 1000 F. Operation will be at the highest steam temperature so far attained in a unit of such capacity, and the generator will be the largest ever constructed for 3600 rpm.

"Practically all turbine-generators from 15,000 kw and up are now hydrogen cooled; and recent advances in seals and gas purification will permit even smaller hydrogen-cooled equipment with resulting increased ope ating efficiencies."

Gas Turbines on Order for Locomotive Drive

The Bituminous Coal Research Development Committee has announced plans for two gas-turbine, pulverized-coal-fired locomotives of 3000 hp each which are expected to be ready for the rails in about 20 months. For one of these a gas turbine has been ordered from the Allis-Chalmers Company and for the other a gas turbine from the Elliott Company. The turbines will drive generators which, in turn, will supply traction motors, although later units may employ mechanical drive.

Operation envisions taking prepared coal up to about 4 in. in size from bunkers carried on the locomotives, then conveying, drying and crushing it to 16-mesh top size. It will then be delivered to a lock hopper or pumped directly to the coal atomizer in which it will be reduced to 90 per cent minus 325 mesh. The pulverized coal will then be air delivered to the combustors under pressure where it will be burned at about 70 lb pressure with air heated in the regenerators to 600 F. The combustion gases will enter the turbine at about 1300 F.

Dr. Vannevar Bush to Receive Hoover Medal

Dr. Vannevar Bush, President of Carnegie Institution of Washington, and wartime director of the Office of Scientific Research and Development, has been named 1946 recipient of the Hoover Medal. It will be formally conferred on Dr. Bush on January 30, at the winter meeting of the American Institute of Electrical Engineers. This society confers the award jointly with the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, and The American Society of Mechanical Engineers.

The Hoover Medal is deemed one of the outstanding honors of the engineering profession. As stated in the organization and by-laws of the Hoover Medal Board of Award, it is given "to honor engineers whose pre-eminent services have advanced the well-being of mankind and whose talents have been devoted to the development of a richer and more enduring civilization."

The award to Dr. Bush will be the ninth. The first medal was given in 1930 to Herbert Hoover, for whom it was named, in recognition of his humanitarian principles and public service.

Electrical Output High

While figures showing the total 1946 output of electricity for public use are not yet available, the Federal Power Commission was able to announce on December 31 that the production for the 12-month period ending November 30, 1946 had amounted to 220,395,280,000 kwhr—a figure only 1.6 per cent below that for the 12-month period ending November 30, 1945, which included a number of months of wartime load. The combined utility and industrial power output for the 12 months ending November 30, 1946 was 266,720,334,000 kwhr.

However, the average daily production of electric energy for public use in November 1946 was 17 per cent above that of November 1945.

The generating capacity of utility plants, as of November 30, 1946 totaled 50,257,598 kw and that of industrial power plants 12,734,776 kw.

F.O.F. Jamboree

The Annual Jamboree of the F.O.F. will be held this year at the Hotel Astor, New York, on the evening of January 31. Founded in 1932 along strictly social lines, this group of men, interested in mechanical and electrical engineering, now numbers about 1800. The annual get-togethers for several years past have been given special designations, such as "Boiler Night" in 1944, "Turbine Night" in 1945 and "Atomic Night" in 1946; and burlesques on these topics have been introduced into the programs. The forthcoming meeting has been designated as "Auxiliary Night." The new president of the club is C. W. E. Clarke, vice president and consulting engineer of United Engineers & Constructors, Philadelphia.

Here is a Sauerman Power Scraper (1½ cu. yd. in capacity) storing coal at rate of 75 tons an hour; making a high, compact pile that fills an area alongside power plant. Scraper can be turned around in a jiffy to reclaim from any part of area. Shifting block in this installation is attached to trolley running on monorail.

It's Easier, Cheaper, Faster
WITH THE
SAUERMAN
One-Man Scraper System

Hundreds of users can tell you how it has put handling and storage on the most economical basis—how it makes better, safer stockpiles, and reclaims coal at only a few cents per ton.

The Sauerman Power Scraper is a *one-man* machine that serves as a self-loading conveyor, with large handling capacity, and long reach. It utilizes full ground space, any size or shape. It builds higher piles, free from air-pockets. It protects from spontaneous combustion. Reduces dust.

There's a Sauerman Power Scraper System to suit your special needs. Our engineers will be glad to advise you.

Write for Complete Illustrated Catalog
SAUERMAN BROS., Inc.
550 S. Clinton St. Chicago 7, Ill.

Export of Coal on Government's Program

Only the highest grade coals that are in surplus and which are offered at prices that prevailed on November 9, 1946, will be directed for shipment on the Government's export program, according to a statement of policy announced by Deputy Solid Fuels Administrator Dan H. Wheeler in setting forth the conditions under which UNRRA and the liberated areas of Europe will purchase a part of their coal requirements through the United States Treasury. The policy became effective as of January 1.

Offers to export coal normally not required in the domestic market, to receive consideration must be accompanied by a chemical analysis of the coal and other detailed information. The statement said:

"UNRRA, through the State Department, and the liberated areas of Europe, through the Reconstruction Finance Corporation, have made arrangements for the purchase of a portion of their coal requirements through the facilities of the Bureau of Federal Supply, United States Treasury Department, at prices not in excess of the maximum prices in effect on November 9, 1946.

"The Solid Fuels Administration for War will receive offers, each month, as hereinafter provided, from any person who has or will have surplus coal available, and, in filling the allocations under this program, will direct shipments to the extent of the tonnage required only of the best coals offered.

"Each direction issued by SFAW will, among other things, specify the period within which the authorized shipments must be made, and will set forth the offered price, which the offerer has represented to be not in excess of the maximum price in effect on November 9, 1946.

"No change of or departure from the terms of any direction may be made, except upon written approval of the Washington office of the SFAW.

"The furnishing of any false or misleading information in connection with the submission of any offer, or the shipment of coal found not to be in substantial conformity with the representations made, may result in the immediate cancellation of any unfilled portions of the direction, the rejection of the shipment before dumping into vessels, the withholding of any future directions, and the imposition of such civil and criminal liabilities as may be provided by law."

Power Train Still in Demand

Once again a 10,000-kw mobile power plant built by the U. S. Navy during the war for emergency service is to be employed to help out during a power shortage. This time it is to supplement the power system of the American & Foreign Power Company at Celaya, Mexico until additional capacity becomes available. The train, it may be recalled consists of six cars carrying boilers, turbine-generator, electrical equipment and fuel oil storage. A similar service was rendered the Salt River Valley Water Users Association in Arizona last summer when hydro power was seriously curtailed.

Tests for Boiler Waters Containing Tannin

Three suitable methods for applying the colorimetric phosphate test to boiler waters containing tannin are described in a report released by the Bureau of Mines.

Tannin in boiler water causes certain difficulties in analytical testing procedures because its colloidal action interferes with the removal of suspended matter by filtration and because it imparts color to the water. In testing for phosphate, tannin may cause some of the suspended material in a sample to become nonfilterable. In this case, it is necessary to eliminate the tannin before filtering to effect complete removal of calcium phosphate.

The three methods used by the Bureau to remove tannin are: potassium nitrate coagulation, potassium persulfate bleach, and tannin removal by decolorizing carbon. Boiler water samples also were tested for phosphate by a more exact gravimetric method, and comparisons were made of the different processes. The report discloses that the three methods compared favorably with the gravimetric test and could be used for ordinary boiler-water-control purposes. Tannin removal by decolorizing carbon was recommended as the quickest and most convenient method for most boiler-water samples.

A 2000-hp Gas Turbine Set

An experimental 2000-hp gas-turbine generator set that weighs only 19 lb per hp, occupies a space of $^1/_4$ cu ft per hp, and can be started in $1^1/_2$ min, was described by **T. J. Putz,** of Westinghouse Electric Corporation, in a paper at the recent Annual Meeting of the A.S.M.E.

The unit operates on the open cycle and burns No. 6 (bunker C) fuel oil to compensate economically for an expected thermal efficiency of 20 per cent at full load. It operates at a top temperature of 1350 F and the blading is of cobalt-chromium-tungsten alloy, with the rotor machined from a solid forging of stabilized 19–9 stainless steel. The cylinder is also of stabilized 19–9 stainless steel and bolting is of K-42-B material.

The turbine develops approximately 6000 hp, of which 4000 hp is used to drive the compressor and the remaining 2000 hp is delivered to the d-c generator through gearing. The full-load speed of the turbine and compressor is 9200 rpm and that of the generator 1200 rpm.

Contemplated applications are for locomotive service, where four of the present units could be installed in a standard cab; for marine auxiliaries; and in the utility field as standby at the ends of transmission lines.

Personals

Nelson L. Smith, of New Hampshire, a member of the Federal Power Commission since 1943, has been elected Chairman to succeed Leland Olds who recently resigned but remains a member of the Commission

Col. William Kelly, long associated with the Buffalo Niagara Electric Corporation, has been designated as chief of the Public Utilities Section of the military government for Germany. He will succeed **Cornelius De Forest,** formerly with the Columbia Gas & Electric System, Cincinnati.

Alexander M. Beebee has been chosen president of the Rochester Gas & Electric Corporation succeeding Herman Russell who becomes chairman of the Board. Mr. Beebee joined this company upon his graduation from Cornell University in electrical engineering in 1915 and became general superintendent of the gas department in 1927. About two years ago he became a vice president of the company.

C. J. Hunter, after many years association with The Dampney Company of America, has recently resigned as Technical Director and is establishing an engineering sales agency for power and mechanical equipment for the New England territory.

T. H. Soren retired on January 1 as vice-president in charge of engineering and power plant construction for the Hartford Electric Light Company and the Connecticut Power Company. He has been succeeded by **F. D. Knight.**

W. T. Reid, for several years past Supervising Engineer of the Bureau of Mines Fuel Section in Pittsburgh, recently left to join the staff of Battelle Memorial Institute, Columbus. He has been succeeded at the Bureau by **R. C. Corey,** lately of the Research Dept. of Combustion Engineering Company.

Obituary

Arvid Peterson, for the past twenty years chief engineer of the Centrifugal and Compressor Department of the De Laval Steam Turbine Company, Trenton, N. J., died on December 19 following a brief illness.

Born in Spanelholm, Sweden, and a graduate of the Royal Polytechnic University of Sweden, Mr. Peterson came to this country in 1905 and two years later entered the employ of De Laval. He was well known in the power field and held memberships in the American Society of Mechanical Engineers, the Propeller Club, American Society of Naval Engineers, Society of Naval Architects and Marine Engineers, the Navy League, American Society of Swedish Engineers, and several fraternal and social organizations. He was a member of the Board of Directors of De Laval.

Edwin D. Grimison, executive assistant in research and development with Babcock & Wilcox Company, died suddenly of a cerebral hemorrhage on January 11 at the age of 41.

A graduate of Lafayette College in 1927, he received his masters degree from Yale the following year and for a brief period was an instructor in mechanical engineering at the latter school. He then became associated with the Fuller-Leigh Company and from 1931 to date was with Babcock & Wilcox Company, except for a period of about three years when he taught at Penn State as associate professor of power engineering and design. Long an active member of the American Society of Mechanical Engineers, he was also the author and joint-author of numerous papers dealing with research problems. His wife and three daughters survive him.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Chemical Proportioning Equipment

%Proportioneers, Inc.%, has issued Bulletin No. 1200 entitled "Treet-O-Control" dealing with a method of combining fluid meters and proportioning pumps so that a given fluid treating process will be continuous. Applications of Treet-O-Control include treating such as adjusting pH and removing hardness and dissolved oxygen in boiler feed and process waters, sampling, blending and diluting. This catalog is a handy reference book on automatic flow responsive equipment and methods in continuous process and includes typical installations and many flow diagrams.

High-Pressure and High-Temperature Flow-Rate Instrument

Bulletin 40-A describes completely armored variable-area flow-rate meters, manufactured by Fischer & Porter Company, Hatboro, Pa. Designed specifically for use where high pressures, high temperatures, possibility of liquid hammer or handling of hazardous gases or liquids makes the use of rotameters with "exposed" glass tubes dangerous or impractical.

This instrument incorporates the newest developments in rotameter flow rate measurement. Its valve body in-a-line construction permits direct horizontal installation into the piping system. It is available as a standard flow-rate indicating meter, or as a recording or recording-controlling or totalizing meter with readings at the meter or at a remote location.

Insulation

A new 20-page manual for power and process engineers, entitled "Control of Industrial Heat and Power Losses" has been issued by the Industrial Mineral Wool Institution, 441 Lexington Ave., New York. It contains descriptions and pictures of the various forms of mineral wool insulation, definitions, conditions and formulas for determining heat loss economies on many types of equipment, together with a "Heat Loss Estimate Sheet" and instructions for its use. Nine case histories, illustrated and fully calculated, cover a variety of typical applications such as piping, flanges, drum heads, driers, boilers, feedwater heaters, ducts, etc.

Industrial Exhausters

Buffalo Forge Company has issued Bulletin 3576 describing its new industrial exhauster which is a heavy-duty steel plate fan with a completely welded housing, adjustable and reversible. Three rotors are available, one for air-handling, two for material. In addition to a description of the exhausters, the bulletin contains capacity rating tables based on velocities, rpm and static pressure, plus installation diagrams and some tables and charts pertaining to pipe and ducts. Also included are descriptions of industrial exhausters for use with hot gases as well as fans to handle corrosive fumes.

Pressure Reducing Valves

The Leslie Company, Lyndhurst, N. J., has issued Bulletin 461 completely illustrated in color and including engineering, operating and maintenance data on pressure reducing valves, differential valves and overflow valves for steam, air or gas services. Also included is a handy index chart which simplifies the selection of the best valve for any specific industrial application including steam supply to air ejectors, dye tanks, kettles, etc.

Remote Control Systems

Remote indicating and control systems, what they are and what they are capable of accomplishing, are explained simply and concisely in a new 12-page engineering bulletin, No. 14B6641, released by the Allis-Chalmers Mfg. Co.

How the transmitter, receiver and indicator of such systems are constructed, how they work, their advantages and specifications are graphically presented with photos, diagrams and charts.

These direct-current remote-indication and control systems have been used in a variety of applications in the oil, metal, power, marine and other fields and include remote control jobs utilizing valves, rheostats, potentiometers, governors, switching devices and combination sequence controls as well as remote indicating systems and remote signaling.

Although basically a direct current device, the system is extremely flexible in application because it can be easily operated on alternating current by the addition of a small rectifier unit.

Remote Recorders

The Brown Instrument Co. has issued Catalog No. 5902 on its New-Matic Remote Transmission Systems for applications where electrical transmission for indicating, recording and control of temperature, pressure, flow and liquid level is neither desirable nor permissible. This 24-page booklet is well illustrated and contains several schematic diagrams of typical applications.

Steam Condensers

A new catalog (No. 1461) illustrating the line of Dual Bank Surface Condensers for central station, industrial and marine use as well as jet condensers, condenser pumping equipment including vacuum pumps, and relief valves, expansion joints and spring supports has been issued by the C. H. Wheeler Mfg. Co. Also included is a section of useful calculation graphs and tables.

Thermix Products

The Prat-Daniel Corporation has just released a new 20-page catalog, No. 200, on draft-producing and dust-collecting equipment.

Detailed descriptions of the Thermix fan-stacks and fans are amply illustrated. Supplementing the tubular dust collector material, is information on the new Thermix duplex collector designed for high collection efficiency. This is accomplished by the use of an electrical or mechanical secondary handling only a small part of the total gas. Additional material included are pages on specific installation problems and the Aerotec tube.

Water Conditioning

"Equipment and Materials for Conditioning Water and Other Liquids" is the title of catalog G just completed by Liquid Conditioning Corp., manufacturers of a line of equipment for water softening, deaeration, etc., as well as a line of Liquonex chemicals. Of particular interest and value is a description of many types of water conditioning processes with explanations of applications, advantages and limitations of each. Also included are tables of the various kinds of gaseous and solid impurities, of chemical reactions, chemical conversion, and others.

A 12-page instruction booklet on water conditioning has been announced by the Allis-Chalmers Mfg. Co. It deals with the importance of feedwater control, the care of testing equipment, obtaining samples and test procedures. Also included are reference tables and a price list of testing equipment and chemicals.

Distribution and Character of Coal Reserves

Only one-third of the total tonnage of coal and lignite reserves of the United States occurs in the Eastern and Interior Provinces. Two-thirds is found in the Great Plains and Rocky Mountain Provinces. However, there is a great difference in rank between the eastern and western coals. Practically all of the Eastern and Interior Province coals, except the anthracitic coals, are caking bituminous coals; and the Appalachian region coals are strongly coking. This region supplies most of the coking coals used in the United States. On the other hand, 80 percent of the Great Plains and Rocky Mountain Province coals are subbituminous coals and lignite. These coals do not cake on heating. As mined, lignite usually contains 28 to 45 percent and subbituminous coal 15 to 28 percent moisture. On exposure to air, the moisture is given off and the coal "slacks" into small pieces. It is not stable and cannot be stored for any length of time except under water, in carefully covered piles, or in closed bins where rapid loss of moisture cannot take place.

COAL RESERVES OF VARIOUS RANKS

Provinces	Billions of net tons			
	Anthracitic	Bituminous	Subbituminous	Lignite
Eastern	15.1	525.2	...	...
Interior	.2	508.0	...	0.1
Northern Great Plains, Rocky Mountain, and Gulf	.1	360.3	763.9	939.4
Totals	15.4	1393.5	763.9	939.5

Lignite and subbituminous coals are used for industrial and domestic fuel in the Dakotas, Montana, Wyoming, Colorado, and western Nebraska. However, the total market is small because of the low density of population in these areas, and these low-rank fuels cannot be shipped very far on account of their low heating value and their tendency to degrade in size, with accompanying possibility of spontaneous ignition.

PERCENTAGES OF VARIOUS RANKS OF COAL COMPRISING THE TOTAL RESERVES

	Per cent of total in equivalent tons of 13,000 Btu coal
Anthracite coal	0.5
Low-volatile bituminous coal	2.5
High-volatile bituminous coal	55.0
Subbituminous coal	23.0
Lignite	19.0
Total	100.0

Most of the bituminous coal in the Western States is free-burning and noncaking. Relatively small deposits of coals suitable for the production of metallurgical coke occur in the Trinidat-Raton field of southern Colorado and northern New Mexico, the Sunnyside beds in the Castlegate field of Utah, and in Pierce and Kittitas Counties, Wash. Some of the coals are slightly caking but do not become plastic enough to form coke that is strong enough for use in the iron blast furnace. In general, it may be said that anthracite and coking coals of metallurgical grade occur in the Eastern Province, coking coals of lower grade and lower bituminous rank in the Interior Province, and noncaking coals of lignitic, subbituminous, and bituminous rank in the Great Plains and Rocky Mountain Provinces.—*From a paper by A. C. Fieldner of the U. S. Bureau of Mines before the A.S.M.E.*

The IMO PUMP provides a maximum of capacity in a minimum of space due to the fact that it can be operated at high speeds connected directly to motor, turbine or other machinery.

Where space is a problem install IMO—the reliable rotary, positive displacement pump having only three moving parts and no gears, pistons, sliding vanes or valves.

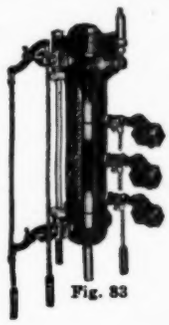
For further information send for catalog I-129-V

IMO means I MOVE OIL

IMO PUMP DIVISION of the
DE LAVAL STEAM TURBINE CO.
TRENTON 2, NEW JERSEY

Specify! FOR BETTER VISIBILITY
Ernst SAFETY

Water Columns HIGH & LOW Alarm



for pressures up to 900 P.S.I.
SPECIAL COLUMNS FOR HIGHER PRESSURES

GAGES and Guards for Boilers Tanks, etc. all Pressures
State your needs

Gage Glasses

Flat, round, and reflex type glasses.
Also mica shields. All sizes.

RUBBER GASKETS
supplied in all sizes
All shipments from stock. Send for catalog.

Ernst WATER COLUMN & GAGE CO.
Livingston, N. J. Livingston 6-1400

BOOKS

1— Piping Handbook 4th Edition

By Sabin Crocker

1376 Pages Price $7.50

This Piping Handbook shows to what extent piping has become a necessary science. The first 860 pages are mainly devoted to an exposition of the principles underlying the performance and structural design of pipes in general, while the remainder of the book covers in detail various piping systems such as were developed for power stations, hydraulic works, etc.

The laws governing the flow of fluids, such as gases, air, water, steam and oil, and their properties, are presented and discussed at length.

Following the laws of fluid dynamics is a brief, but valuable, chapter on the metallurgy of pipes and a complete collection of data on pipe fittings as they are now standardized by the various interested branches of industry.

Of necessity the chapter on heat insulation is short, but the information will enable the designer to solve a large percentage of his pipe insulation problems. Stress analysis of piping is treated in part graphically.

Mr. Crocker has enlarged on the practical application of piping by the addition of chapters on refrigeration and gas piping, corrosion, and hydraulic power transmission piping. The present edition is much more comprehensive than the 1930 edition.

2—Inspection Handbook for Manual Metal-Arc Welding

156 pages Price $1.50

This handbook, prepared by the American Welding Society, is the most complete and authoritative manual that has yet been published on welding inspection. It covers the requirements and duties of a welding inspector, methods of testing welds, and contains a comprehensive description of weld inspection by visual, magnetic-particle and radiographic methods. One section discusses the principal types of weld defects and indicates how they may be detected and corrected. The book is written in simple language and is intended to serve as a reliable source of information on any welding inspection problem.

3—Elementary Mechanics of Fluids

By Hunter Rouse

376 pages $6 \times 9^1/_4$ Price $4.00

The author has adopted a method of presentation differing from the conventional that is unique yet makes readily understandable the principles underlying the manifold uses in today's engineering of fluid flow. This is accomplished by development of the usual equations for flow of fluids starting from the basic equations of mechanics. Derivations are readily followed. Problems are included, both as examples of application of the text and of a nature akin to those the practicing engineer encounters.

The book contains eleven chapters, namely Introduction to the Study of Fluid Motion, Fluid Velocity and Acceleration, Pressure Variation in Accelerated Flow, Effects of Gravity on Fluid Motion, One Dimensional Method of Flow Analysis, Effects of Viscosity on Fluid Motion, Surface Resistance, Form Resistance, Lift and Propulsion, Surface Tension, The Role of Compressibility in Fluid Motion. There is also an appendix in which is summarized useful information on the application of the principles of dimensional analysis and on the mechanical properties of commonly used liquids and gases.

4—Statistical Thermodynamics

By Erwin Schrödinger

88 pages 5×7 Price $1.50

This is a course of seminar lectures delivered at the School of Theoretical Physics, Dublin Institute for Advanced Studies, the object of which, according to Professor Schrödinger, was "to develop briefly one simple, unified, standard method capable of dealing, without changing the fundamental attitude, with all cases and with every new problem that may arise." The text, which is far from elementary and comprises considerable mathematical analysis, is intended for the more advanced student of thermodynamics.

The author has condensed those topics which appear in many textbooks but has dealt at greater length with vital points which are usually passed over in all but large monographs. He discusses two different attitudes as regards the physical application of the mathematical result.

5—Thermodynamic Properties of Air

By Joseph H. Keenan and Joseph Kaye

73 pages $7^1/_2 \times 10$ Price $2.50

This book was brought out to meet the need for working tables on properties of air in connection with gas turbine studies, as well as in the solution of problems in regenerative heating and the expansion of air from states of high temperature. Included are values for viscosity, thermal conductivity conversion factors and tables and typical examples.

6—Graphical Symbols for Electric Power and Control

Price 40 cents

The American Standards Association recently issued these Graphical Symbols. Sponsored by the A.S.M.E. and A.I.E.E., these symbols were prepared by representatives of various bodies that have occasion to employ such symbols.

7— Water Treatment and Purification—2nd Edition

By William J. Ryan

270 pages Price $2.75

Since the publication of the first edition of this book, in 1937, considerable advancement has been made in water treatment and new or improved processes have been developed. The present edition attempts to bring the reader up to date.

The text includes chapters on: impurities in water; sedimentation and coagulation; filtration; analysis of water; lime and soda-ash process; ion exchangers; boiler feedwater treatment; disinfection of water; tastes and odors; miscellaneous treatments; and the prevention of corrosion. A general appendix contains tables of equivalents, conversion factors, atomic weights, compound formulas, and the more common chemical reactions associated with water treatment. Typical process equipment is illustrated.

For plant engineers and plant operators the value of the book lies in the fact that the author has succeeded in presenting the essentials of water treatment and purification in a readily understandable form. The book is not written for the chemist or water specialist, but rather for the engineer who needs a general knowledge of the subject.

COMBUSTION PUBLISHING COMPANY, Inc., 200 Madison Avenue, New York 16, N. Y.

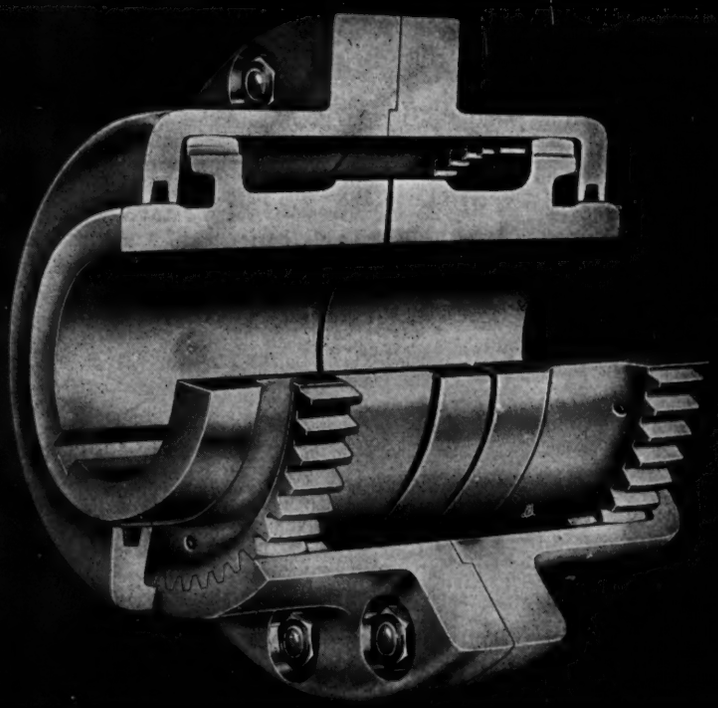
Enclosed find check for $. . . . . .for which send me the books listed by number.

NAME_____ **Book Nos.**_____

ADDRESS_____

Postage prepaid in the United States on all orders accompanied by remittance or amounting to five dollars or over.

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.

Advertisers in This Issue

Air Preheater Corporation, The..... 15
Armstrong Cork Company..... 6
Theo. Audel & Company, Publishers... 37
Bailey Meter Company..... 4
Bayer Company, The..... 10
Beaumont Birch Company..... 39
Buffalo Forge Company..... 12
Cochrane Corporation..... 19
Combustion Engineering Company, Inc. .....Second Cover, 8 and 9
Combustion Publishing Company—Book Department..... 47
De Laval Steam Turbine Company..... .....18 and 46
Diamond Power Specialty Corporation. .....Third Cover
Edward Valves, Inc..... 5
Electric Machinery Mfg. Company..... .....Fourth Cover
Ernst Water Column & Gage Company 46
Flexitallic Gasket Company 42
Infilco Incorporated..... 14
Ingersoll-Rand Company..... 17
National Aluminate Corporation..... 22
Northern Equipment Company..... 2
Poole Foundry & Machine Company.. 48
Wm. Powell Company, The..... 13
Refractory & Insulation Corporation.. 34
Research Corporation..... 21
Sauerman Bros., Inc..... 43
Stock Engineering Company..... 40
Thermix Corporation, The..... 20
Todd Shipyards Corporation, Combustion Equipment Division..... 7
Vulcan Soot Blower Corporation..... 16
Western Precipitation Corporation..... 11
Yarnall-Waring Company 3